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OPERATIONS AND MAINTENANCE MANUAL FOR MULTI-PHASE EXTRACTION AND TREATMENT SYSTEM NAS CORPUS CHRISTI TX

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MORRISON KNUDSEN CORPORATION

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Operations and Maintenance Manual
Multi Phase Extraction and Treatment System

Naval Air Station Corpus Christi
Corpus Christi, Texas

Contract No. N62467-93-D-1106

August 1998

Revision 0

Southern Division
Naval Facilities Engineering Command
North Charleston, South Carolina
29419-9010

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NAVAL AIR STATION CORPUS CHRISTI
CORPUS CHRISTI, TEXAS

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1.0
INTRODUCTION

1.1 PURPOSE AND USE OF THE OPERATIONS AND MAINTENANCE MANUAL

This manual provides the requirements and procedures for operating and maintaining the multi-phase extraction system at Naval Air Station (NAS) Corpus Christi. It is intended to serve as the primary source of information for operating and maintaining the system including routine operations, routine maintenance and scheduled inspections. The information is organized in the following major topic sections:

- Introduction
- General Description
- System Operation in Automatic Mode
- Individual Well Testing
- Manual Operation
- Control of Air Emissions
- Mass Recovery Estimate
- System Operation and Maintenance
- Freeze Protection
- Removal of Stored Hydrocarbon and Water
- System Check Sheets
- Troubleshooting Guide
- Attachments:
    1. As-built Drawings/List of Components
    2. O&M Data Forms
    3. Orifice Plate Documentation
    4. Standard Air Permit Exemption and Related Correspondence
    5. Condensate Collector (T-7) and Condensate Transfer Pump
    6. Bag Filter (F-1)
    7. Gauge Chart for Product Tank (T-4)
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    9. Miscellaneous Information
    10. Nepcco Groundwater Remediation System Manual
    11. Thermtech, Inc., Operation & Maintenance Manual
    12. Scale Prevention and Dispersant Chemicals and Pumps

2.0
GENERAL DESCRIPTION

The multiphase product recovery system installed at NAS Corpus Christi consists of a skid mounted Liquid Ring Vacuum (LRV) Pump (VP-1) with a moisture separator (T-1) and seal water tank (T-2), an oil/water separator (T-3), a product tank (T-4), a transfer tank (T-5), a storage tank (T-6), a vapor stream condensate separator (T-7), and a thermal oxidation unit for off gas treatment. Details of equipment mounted LRV skid, the electrical diagrams, part lists, and equipment specifications for most of the treatment equipment are included in the Operations and Maintenance (O&M) Manual as Attachment 10, provided by NEPCCO, the LRV equipment supplier. The same component identification numbers are used in both the NEPCCO and AES drawings. Detailed information concerning the thermal oxidation unit is provided in the ThermTech Operations and Maintenance Manual, Attachment 11.

The equipment is installed in an equipment compound consisting of a bermed concrete equipment pad, a bermed storage tank pad, a thermal oxidation unit pad, and a security fence. The general equipment layout is shown in Attachment 1 as Figure 1. The Process Flow and Instrumentation Diagram is provided as Figure 3. An as-built drawing of the concrete pads is shown in Figure 4.

As shown in Figure 3 of Attachment 1, groundwater, separate phase hydrocarbon, and subsurface vapor are drawn from each vacuum well by the LRV pump (VP-1) through a bag filter (F-1) into the moisture separator (T-1). The groundwater and separate phase hydrocarbon are pumped from the moisture separator (T-1) to the oil/water separator (T-3) by a submersible transfer pump (P-1) in T-1. From the oil/water separator, the separate phase hydrocarbon passes to the product tank (T-4), where it is stored until removal for recycling or disposal. The groundwater feeds from the oil/water separator (T-3) through gravity flow to the water transfer tank (T-5). From T-5, the groundwater is pumped by a transfer pump (P-2) to the water storage tank (T-6), where it is stored until it is automatically transferred to the Industrial Wastewater Treatment Plant. Flow meter FQ-1 meters the total fluid pumped into the storage tank (T-6). Flow meter FQ-2 measures the amount of makeup water (base water) supplied to the system.

The seal water tank (T-2) serves as a reservoir for water used as the seal for the liquid ring vacuum pump (VP-1). When the seal water level drops too low in T-2, a solenoid valve (SV-3) opens to add water from the groundwater storage tank (T-6). Optionally, low level in T-2 is also wired to open solenoid valve (SV-2) if adding potable water to T-2 is desired. Seal water in T-2 continually flows through the adjustable flow meter (FI/FC-2) into T-1 to draw away heat generated by the liquid ring vacuum pump. This adjustable flow meter must be at least slightly open during operation in cold weather, and opened to at least 1.5 gallon per minute during hot weather.

Scale prevention and dispersant chemicals are metered into the system between the transfer pump (P-2) and the groundwater storage tank (T-6) to minimize scale in the vacuum pump (VP-1). These chemicals are also intended to disperse algae accumulation in the system sight glasses and polyethylene storage tanks. Information concerning these chemical additives is included in Attachment 12.

The vapor phase recovered from the well passes through the moisture separator (T-1), the liquid ring vacuum pump (VP-1), and into the seal water tank (T-2). The vapor phase then passes through two orifice meters (GOM-2 and GOM-3) and out through the condensate collector (T-7) to the thermal oxidation unit. The flow rate is determined by measuring the differential pressure across the orifice meters. Documentation for orifice meters is provided in Attachment 3. The condensate collected in T-7 is automatically transferred to the oil/water separator (T-3) by a transfer pump (P-3).

The thermal oxidation unit uses natural gas as the auxiliary fuel. The unit is provided with a combustion air blower, a dilution air blower, an automatic dilution air control valve, and a flame arrestor to prevent burn back down the vapor phase piping. A chart recorder documents the thermal oxidation temperature continuously. A Process Flow and Instrumentation Diagram of the thermal oxidation unit appears in

Section XII of Attachment 11. The Standard air permit exemption and related correspondence are included in Attachment 4.

The LRV system can be operated in automatic mode or manual mode, as selected at the LRV control panel. **Manual mode is not recommended.** In the automatic mode, the LRV system will draw from up to the five motor valves, connected to eight wells one at a time. During normal operation one to three wells will be used at a time. The system must be manually switched to change from one well to another. When the system is operated in the automatic mode, all fail-safe shutdown alarms are in effect, including high level alarms in the moisture separator (T-1), the seal water tank (T-2), the product tank (T-4), the water transfer tank (T-5), the water storage tank (T-6), and the sump. If one of the above alarms is activated, the control panel activates the automatic dial-out on the telephone modem installed in the control panel, notifying the selected telephone numbers with a recorded message concerning the alarm condition. Shutdown of the thermal oxidation unit will also shut down the LRV system and activate the automatic dial-out. In addition, if the LRV pump motor draws too much current and causes the overload relay (M621) to trip, the system will dial out the alarm message but not shut down the thermal oxidation unit. If the liquid level high level alarm is reached in the condensate collector (T-7), it will trigger an alarm condition in the thermal oxidation unit, shut down both the LRV system and the thermal oxidation unit, and dial out the alarm message.

When the system is operated in the manual mode, one or more wells can be manually selected for recovery. The system will recover from those wells until the settings are manually changed at the control panel. **When the system is operated in the manual mode, the fail-safe shutdown alarms on the LRV control panel are not operable. If the thermal oxidation unit shuts down during manual operation, the liquid ring vacuum pump must be immediately turned off manually to prevent continued supply of flammable vapors into the hot incineration chamber.**

2.1 RECOVERY WELLS

Eight recovery wells (MW-13, MW-14, MW-20, MW-21, MW-22, MW-26, MW-29, and RW-03) are connected to the remediation system and enter the compound through five lines. The piping from the recovery wells enters the equipment compound through a vault located in the northeast corner of the compound which also serves as a sump for the compound. The wells are connected to an automated manifold which determines which well is in operation. The general site layout, including the location of the recovery wells, is shown in Figure 2. In addition to the five lines connected to the system there are seven additional connections in the vault for as many as seven future wells. Each of the seven future lines in the vault extend beyond the sides of the concrete pads, and are plugged and buried for future access.

The recovery wells are equipped with a drop pipe which can extend to a depth of two feet below the historic groundwater low level for the well. The drop pipe may be adjusted up or down as required to maintain groundwater at a desired level. The wellhead installations are shown in Figure 5. Table 1 provides the current historic groundwater low level for each well, as well as the most recent drop tube setting.

2.2 LIQUID RING VACUUM PUMP

The LRV pump (VP-1) consists of a Fluid Vac ® Model A-75 pump manufactured by Atlantic Fluidics. The LRV pump has a 5 HP, 240 Volt, single phase motor. The LRV pump is capable of producing a vacuum of up to 25 inches of mercury and a flow rate up to 100 cfm. Detailed information on the LRV pump is located in Attachment 10, Section 2.

TABLE 1 DROP TUBE SETTING LEVELS		
RECOVERY WELL	DEPTH TO HISTORIC LOW CORRECTED GROUNDWATER LEVEL*	DEPTH TO BOTTOM OF DROP TUBE ON July 20, 1998*
MW-13	12.33	13.46
MW-20	12.60	14.00
MW-21	11.44	12.38
MW-26	13.75	14.75
MW-29	9.68	10.68
MW-22	14.49	14.45
MW-14	10.85	12.84
RW-03	10.18	12.12

* Depths are from the top of the casing

2.3 TRANSFER PUMPS

Two transfer pumps are used for transferring liquid from one tank to another within the system. Transfer pump, P-1, is located in the T-1 tank. P-1 is used to transfer liquid from the T-1 tank to the oil/water separator. P-1 is a submersible Total Fluids Pump Model #18G1514. The operating range of P-1 is 10.1 gpm to 20 gpm. The P-1 pump has a 1 ½ HP, 240 Volt 1 phase motor.

Transfer pump, P-2 is located near the T-5 tank. It is used to transfer water from the T-5, 550 gallon water storage tank to the T-6, 5000 gallon water storage tank. The P-2 pump is a Myers Model 100M-1/2 with a 3 15/16 inch impeller. P-2 has a ½ HP, 240 Volt 1 phase motor. Detailed information on P-2 pump is located in Attachment 10, Section 3.

Transfer pump P-6 is located within the secondary containment area surrounding T-6. It is used to automatically transfer water from the T-6, 5000 gallon water storage tank, to the water treatment system. The P-6 pump is a Teel centrifugal pump, and has a 1/3 HP 115 Volt 1 phase motor.

2.4 OIL/WATER SEPARATOR

The oil/water separator, T-3, consists of a NEPCCO Petropurge Cylindrical Oil Water Separator. Model number OP-12. The oil/water separator is designed to handle up to 12 gpm flow. The separator separates sludge, oil and water. An inlet chamber removes gross solids and trash from the influent stream and distributes the flow evenly throughout the separating chambers. An inlet pipe directs the flow towards the separator bottom. An inlet sludge/diffusion baffle separates the inlet flow and directs it to the middle of the coalescing tubes. The separator chamber consists of coalescing tubes which separates the oil from the water. A sludge chamber collects the settleable solids which have collected on the separator floor. Detailed information on the oil/water separator is located in Attachment 10, Section 4.

2.5 CONTROL PANEL

The multi-phase recovery system is controlled by an Allen Bradley Programmable Logic Controller (PLC). The control logic is described in Attachment 10, Section 1. Detailed information on the PLC is provided in Attachment 10, Section 5.

2.6 TANKS

The multi-phase recovery system consists of seven tanks T-1 through T-7. T-1 is a moisture separator tank. Vapor and liquid recovered from the recovery wells, enters T-1. The vapor phase recovered from the well passes through the moisture separator (T-1), through the liquid ring vacuum pump (VP-1), and into the seal water tank (T-2). Liquid is pumped out of the T-1 tank to the oil/water separator (T-3). Tank T-2 is also a moisture separator and serves as a reservoir for water used as the seal for the liquid ring vacuum pump (VP-1). When the temperature of the seal water in the seal water tank (T-2) exceeds 125 degrees Fahrenheit, or when the seal water level drops too low in T-2, a solenoid valve (SV-3) opens to add water from the groundwater storage tank (T-6). Tank T-3 is the oil/water separator and is discussed in Section 2.4. Tank T-4 is a 150 gallon product storage tank. A tank gauge chart is provided as Attachment 7. Tank T-5 is a 550 gallon vertical polyethylene storage tank used for temporary water storage. Additional information on the T-5 tank is provided in Attachment 8. Water gravity flows from the oil/water separator to the T-5 tank. The water is then automatically pumped from the T-5 tank to the T-6 water storage tank. The T-6 tank is a 5000 gallon vertical polyethylene tank used for water storage prior to transferring the water to the base water treatment system. Additional information on the T-6 tank is provided in Attachment 8. The T-7 tank is a moisture separator designed to removed entrained liquid from the vapor stream prior to entering the thermal oxidizer. Detailed information on the T-7 tank is provided in Attachment 5.

2.7 THERMAL OXIDIZER

The thermal oxidizer is used to treat the off-gas from the vacuum extraction system. The thermal oxidizer consists of a Thermtech VAC-10 thermal oxidizer. The thermal oxidizer is designed to operate at 1410 °F and to retain the heated vapors for a minimum on 1 second to ensure proper destruction. Detailed information on the thermal oxidizer is provided in Attachment 11.

2.8 BAG FILTER

A bag filter F-1 is located between the manifold and the T-1 tank. The filter consists of a Filter Specialists Inc. Model BFN 12. The filter is designed to remove sediments from the incoming vapor/liquid before entering the T-1 tank. Detailed information on the filter is provided as Attachment 6.

2.9 MISCELLANEOUS COMPONENTS

Detailed information on miscellaneous components including ball valves, pressure reducing valves, electrical wire coatings, temperature control switch, float switch for T-2 tank, gas meter, gas regulator, and paints is included in Attachment 9.

2.10 SCALE PREVENTION AND DISPERSANT CHEMICALS AND PUMPS

Scale prevention and dispersant chemicals are metered into the system between the transfer pump (P-2) and the groundwater storage tank (T-6) to minimize scale in the LRV pump (VP-1). The chemicals are metered into the system using LMI P131-1905 metering pumps (P-4 and P-5). NALCO® 8357 is used for scale prevention and Dynacool ® 8301-D is used as a dispersant to prevent material from adhering to surfaces. These chemicals are also intended to disperse algae accumulation in the system sight glasses and polyethylene storage tanks. Information concerning these chemical additives is included in Attachment 12.

3.0
SYSTEM OPERATION IN AUTOMATIC MODE

3.1 PRE-START CHECKS

Before starting the system, the operator should set the drop pipe in each of the recovery wells to the desired depth. This is done by loosening the worm gear clamp on the Fernco fitting around the one inch drop pipe at the top of the well casing, lowering or raising the pipe, and tightening the clamp. The gate valve located on the side of the stick-up cover should be fully open. All motor valves should be in the closed position as indicated by horizontal red indicator handles located on the valves.

At the manifold located in the equipment compound, the operator should ensure that the recovery line from the selected recovery well is connected with a hose to one of the motor valves on the manifold. The gate valves (GV-1 through 5) located below the motor operated valves (MV-1 through MV-5) must be at least partially open, and may be used to increase or decrease the vacuum on the wells. It may be desirable to crack the ambient air valve (GV-6 through 10) located between the gate valve and the motor operated valve to reduce the vacuum pressure on the well. Prior to start-up, the operator should verify that all valves are in the proper open or closed position. A detailed start-up procedure for the NEPCCO equipment is included in Section 1 of the NEPCCO manual provided as Attachment 10.

3.2 START-UP

The following steps should be followed when starting the multi-phase extraction system.

1. Position valves in the proper open and closed position.
2. Place control switches on the FP-1 control panel in the "auto" position. Place the motor valve switches in auto for the motor valves that will be operated. Leave other motor valve switches in the off position.
3. Turn the main switch to "run". Refer to Figure 8 in the NEPCCO manual for a diagram of the control panel.
4. Within 60 seconds, turn the thermal oxidation controls to "On" and "Low Fire". Ensure no alarm lights are lit on the thermal oxidation control panel.
5. Check that the combustion air blower (B-1003) on the thermal oxidizer is operating.
6. Listen for a click that will indicate that the pilot light fuel is being added by the pilot solenoid valve (XV-101).
7. Check for the presence of a pilot light flame as indicated by a voltage reading on the thermal oxidation unit control panel.
8. Check that the booster blower (B-1002) has automatically turned on when the temperature in the oxidizer reaches 140 degrees Fahrenheit.
9. Listen for a second click indicating that the unit is ready to operate.
10. Pull the handle forward on the main natural gas solenoid (XV-104) and turn the oxidizer control from "Low Fire" to "Run".
11. When the thermal oxidizer reaches approximately 1360 degrees Fahrenheit, the "AL2" light will become lit on the upper temperature control and the liquid ring vacuum pump system will automatically turn on. The timer for the first motor valve (MV-1) on the manifold starts at this time. The oxidizer temperature will continue to rise until it reaches 1410 degrees Fahrenheit.
12. Check the vacuum gauge (PI-1) located below MV-1 for a vacuum pressure. Adjust the ambient air valve below the motor valve or the gate valve below the ambient valve to achieve the desired vacuum operating range for that well.
13. Check the clear plastic tubing in the manifold, to determine if any well fluids are being recovered.

3.3 NORMAL OPERATION

The system has been designed to recover groundwater, free phase product, dissolved phase product, and vapors simultaneously from multiple recovery wells. In the normal operating mode, with all control panel switches in the "auto" mode, the five motor operated valves in the well manifold will all be open. Due to loss of vacuum across multiple wells no more than three wells are recommended to be open at a time and depending on the field conditions, it may only be possible to operate one well at a time. The well selected for operation should be determined during the scheduled maintenance by measuring the product level in the wells and operating the well with the most product in it.

The butterfly valve (BFV-1) prior to the LRV pump (VP-1) can be partially closed to reduce the vacuum on all of the recovery wells. Optionally, the ambient gate valve (GV-11) on top of the moisture separator (T-1) can be slightly opened to reduce the vacuum on all of the recovery wells.

While the system is operating, the operator should check all pressure and vacuum gauges, thermometers, flow meters and flow totalizers, and tank levels, and record the data onto the O&M Data Sheet in Attachment 2. The operator should measure the pressure on the upstream side of each orifice meter and the pressure differential between the two ports on each orifice meter using a digital manometer. The vacuum pressure at the recovery well from the gauge located on the side of the stick-up cover should be recorded. The difference between the well gauge and the manifold gauge is the pressure loss due to line friction. Increases in the difference between these two gauges may indicate scale buildup or bacterial fouling in the recovery lines. A sudden drop in the well vacuum reading may indicate a parted line. Normal operating ranges for instrument readings are provided in Table 2.

The thermal oxidation unit is programmed to operate at 1410 degrees Fahrenheit. If the stack temperature exceeds 1570 degrees, the thermal oxidizer and the liquid ring vacuum pump will shut down and activate the alarm dial-out. If the combustion chamber temperature falls below 1360 degrees, the liquid ring vacuum pump will be turned off, but the thermal oxidizer will continue to operate. When the combustion temperature again reaches 1360 degrees, the liquid ring vacuum pump will turn on again.

After recording all data, the operator should monitor the system to ensure proper operation.

Gate valves GV-12 and GV-14 are used to throttle the transfer pumps. The flow should be adjusted as required to control flow rates of water into the oil/water separator (T-3) and the storage tank (T-6). The flow needs to be balanced so that the flow into any tank does not exceed the flow out of the tank. All pressure readings from gauges PI-8 and P-9 should be recorded.

The butterfly valve (BF-2) is used to throttle the flow of recovered vapor to the thermal oxidation unit. The pressure gauge (PI-301) before BF-2 should indicate a slight pressure on the vapor coming from the liquid ring vacuum pump system. The pressure gauge (PI-302) after BF-2 should indicate a vacuum between 5 and 10 inches of water at all times to ensure the thermal oxidation unit can obtain enough dilution air and not emit recovered vapor out the dilution air intake.

Storage tanks in the compound are connected to the moisture separator (T-1) by a one inch hose with a gate valve (GV-13) located at the top of the moisture separator (T-1). It is possible to pull a slight vacuum on the product tank (T-4), transfer tank (T-5), and the storage tank (T-6) by cracking open GV-13. **The Operator must verify that all tanks are vented to prevent collapsing the tanks.** By pulling a slight vacuum on the tanks, the buildup of vapors within the vessels is lessened.

TABLE 2
NORMAL OPERATING RANGES FOR GAUGE READINGS

PARAMETER	GAUGE SYMBOL	NORMAL OPERATING RANGE
Temperature in seal water tank (T-2)	TI-1	55 - 120 degrees F
Temperature of vapor effluent stream	TI-2	80 - 120 degrees F
Vacuum pressure at recovery well (needs to be multi-phasing)	-	8 - 25 inches Hg
Vacuum pressure at manifold	PI-1 through PI-5	8 - 25 inches Hg
Vacuum pressure before butterfly valve (BFV-1)	PI-6	10 - 27 inches Hg
Vacuum pressure after butterfly valve (BFV-2)	PI-7	10 - 27 inches Hg
Discharge pressure from moisture separator (T-1) and transfer pump (P-1)	PI-8	30 - 85 psi
Discharge pressure from water transfer tank (T-5) and transfer pump (P-2)	PI-9	23 - 28 psi
Flow meter from seal water tank (T-2) to liquid ring vacuum pump (VP-1)	FI/FC-1	NA
Adjustable flow meter from seal water tank (T-2) to moisture separator (T-1)	FI/FC-2	0.5 - 2 gpm
Adjustable flow meter leading to liquid ring vacuum pump (VP-1)	FI/FC-3	1.0 - 4.0 gpm
Differential pressure across 2" diameter orifice meter for air stream from moisture separator (T-1) to seal water tank (T-2)	GOM-1	NA
Differential pressure across 2" diameter orifice meter for air effluent from seal water tank (T-2)	GOM-2	NA
Differential pressure across 1" diameter orifice meter for air effluent from seal water tank (T-2)	GOM-3	0.1 - 100 inches of water when pulling from well; 150 - 160 inches of water when pulling ambient air only
Burner temperature	-	1400 - 1415 degrees F
Stack temperature	-	1375 - 1405 degrees F
Differential Pressure Diluted Process Air	FI-309	0.07 - 0.085 inches of water
Natural Gas Pressure	PSH-106	18 - 20 inches of water
Incoming Process Air Pressure	PI-301	-10 to +120 inches of water

TABLE 2 (Continued) NORMAL OPERATING RANGES FOR GAUGE READINGS		
PARAMETER	**GAUGE SYMBOL**	**NORMAL OPERATING RANGE**
Process Air Vacuum (after BF-2)	PI-302	5 - 10 inches of water (vacuum)
Differential Pressure on Natural Gas	PI-107	0.1 - 2 inches of water
Differential Pressure on Burner	PDI-501	0.3 - 0.75 inches of water
Diluted Process Air Temperature	TI-307	80 - 120 degrees F
FID Concentration at BF-20	-	Less than 11,000 ppm
FID Concentration at stack	-	Less than 100 ppm

There are four valves inside or exiting the bermed area around the 5,000 gallon water storage tank (T-6). The first, BV-9, is located on the side of the tank and may be used to empty the tank for maintenance or to transfer recovered groundwater to a vacuum truck. The second, GV-17, is located outside the berm next to the curb. This valve is the load valve for transferring tank contents into a truck for disposal at the Industrial Wastewater Treatment Plant. GV-18 is located next to GV-17. This valve, in case of catastrophic failure of T-6 may be used to drain the bermed area into a vacuum truck for disposal at the water treatment plant. The last valve, GV-15, is located in the sump inside the equipment berm. This valve may be opened to drain collected rain water from the storage tank berm into the sump. The control system will automatically open MV-6 as needed to drain the collected water in the sump into and through the treatment system.

3.4 SHUT DOWN

3.4.1 Emergency Shut Down

The system can be shut down in an emergency by pressing the emergency stop button located on the thermal oxidizer panel control panel. This will shut down all systems and equipment.

3.4.2 Normal Shut Down

The following steps should be taken to shut down the system under non-emergency situations.

1. Turn all switches on the LRVP control panel (FP-1) to the off position.
2. Press the "Emergency Stop" button on the thermal oxidizer control panel.

4.0
INDIVIDUAL WELL TESTING

On occasion, it may be desirable to determine the recovery rates from an individual well for a given period of time, such as a twenty four hour test. To test an individual well follow the steps listed below:

1. Turn the control switches for all motor valves to the "off" position except the desired well. (This will close all the valves which are in the "off" position.)
2. Leave the desired well switch in the "auto" position.
3. Leave the VP-1 switch in the "auto" position as well.
4. Turn the main switch to "run".
5. Check and record all gauges, tank levels, etc. before placing the well in test mode.

One or more wells may be tested by placing one or more valve switches in the "auto" position.

5.0
MANUAL OPERATION

Another operating option is to place an individual well in a continuous run mode in manual operation, however, this is not a desirable operating mode. This may be done by placing both the switch for the motor valve leading to the desired recovery well and the VP-1 switch in the "hand" position. Place the other motor valve switches in the "off" position. Ensure that the control switches for P-1 and P-2 remain in the "auto" position. Any or all of the wells may be placed in the continuous run cycle at one time. This will cause the system to operate outside of the normal automatic run loop. **Manual operation should not be necessary under normal circumstances. System shut down safety switches will be bypassed. Do not leave the system unattended in the manual mode. If the thermal oxidation unit shuts down, the liquid ring vacuum pump must immediately be manually turned off.**

6.0
CONTROL OF AIR EMISSIONS

The system must be operated in accordance with Standard Exemptions 68, 88, and 118 authorized by the Texas Natural Resource Conservation Commission (TNRCC) in 30 TAC Section 116.211. Copies of the correspondence from the TNRCC concerning this site and Standard Exemptions 68 and 118 are provided in Attachment 4. Maximum allowable emissions as stated in the exemptions or calculated from site conditions are provided in Table 3. Calculations for the allowable benzene emission rate is based on a distance of 400 feet to the nearest receptor (admiral's residence).

TABLE 3
MAXIMUM ALLOWABLE EMISSION RATES

Parameter	Maximum allowable emission rate
Total Petroleum Hydrocarbons (TPH)	1.0 lb/hr
Benzene	0.029 lb/hr

A thermal oxidation unit is used to burn the recovered vapors before discharge to the atmosphere. On each weekly site visit, the operator should use a Flame Ionization Detection (FID) meter to check the stack effluent. The oxidation unit qualifies under the standard exemptions if it continues to operate with a combustion temperature greater than 1400 degrees Fahrenheit. The destruction efficiency must be greater than or equal to 97.5%, and the incoming recovered vapor concentration should not be greater than 110,000 parts per million of total petroleum hydrocarbon (TPH). A chart recorder continuously records the combustion temperature.

If the recovered vapor concentration is greater than 110,000 parts per million of TPH, the butterfly valve (BFV-1) before the air-water separator (T-1) can be closed slightly, or the ambient valve (GV-11) on top of the moisture separator (T-1) can be opened slightly, to reduce the vacuum induced on the recovery wells. If only one well is yielding high concentrations, the vacuum induced on that well only may be reduced by slightly opening the ambient gate valve beneath the motor valve for that well on the manifold, or by partially closing the gate valve below the ambient valve on the manifold.

Optionally, the concentration of the recovered vapor can be reduced by raising the drop pipe in the well above the water table. Once vapor concentration is reduced over time, the drop pipe may be lowered back to the historic groundwater low level for that well to maximize multi phase recovery.

The concentration of the effluent vapor should be monitored as described in Section 8.0.

Air emissions compliance should be documented monthly on the Form TV10 Thermal Oxidizer Report included in Attachment 2.

7.0
MASS RECOVERY ESTIMATES

Mass recovery estimates may be made from individual well test data by collecting samples and recording recovery rate data. Total mass recovery is the sum of the recovery in each of the three phases: free product, dissolved phase in the groundwater, and vapor phase. During a well test, the amount of free product recovered can be determined by measuring the product in the product storage tank (T-4) before and after the test. The levels should be measured using a yardstick and color change paste.

The amount of dissolved phase recovered can be determined by multiplying the amount of groundwater recovered by the concentration of total petroleum hydrocarbons (TPH) in the water. A sample of recovered groundwater can be collected from the sample port (SP-7) between the groundwater transfer pump (P-2) and the groundwater storage tank (T-6). The quantity of groundwater recovered from the well can be determined by measuring change in water level in the water transfer tank (T-5) and adding it to the change in water level in the water storage tank (T-6) during the well test.

The amount of vapor phase recovered can likewise be determined by multiplying the flow rate of the vapor phase effluent by the concentration of TPH in the vapor phase. During the well test, a vapor sample may be collected from one of the ports on GOM-2 using a summa canister. In order to determine the vapor flow rate, record the differential pressure using a digital manometer at the 1" diameter orifice plate (GOM-3) located between the seal water tank (T-2) and the condensate recovery tank (T-7). Also record the temperature from the temperature probe adjacent to the orifice plate (TI-2) and the vapor stream pressure upstream of the orifice plate using the digital manometer. Using the table for the orifice plate (Eclipse model #SBO-X-1) provided in Attachment 3 and adjusting for the pressure and temperature using the equation in Attachment 3, vapor flow rate can be estimated.

Alternatively, the amount of vapor phase recovery can be determined by collecting a vapor sample of the diluted process vapor stream from BV-20 on the thermal oxidation unit using a summa canister. Record the differential pressure on the diluted process air (FI-309) on the thermal oxidizer. Also record the temperature from the temperature probe adjacent to BV-20 (TI-307).

A rough estimate of the vapor phase recovery rate for a well can be calculated by substituting an FID reading from a port on GOM-2 or from BV-20 for the TPH concentration determined by an analytical laboratory. This calculation can be done either during an individual well test or during normal operation of the system.

8.0
PREVENTATIVE MAINTENANCE

8.1 WEEKLY OPERATION AND MAINTENANCE REQUIREMENTS

The following maintenance procedures should be performed on a weekly basis. Forms provided in Attachment 2 should be used to record data and tasks performed. All forms should be maintained by the operator or submitted to designated Navy personnel.

1. Inspect the compound for general appearance. Keep garbage removed from the compound. If necessary, place a garbage container inside the fence for garbage collection and empty on a regular basis.

2. Upon entering the compound, check the control panel for any system shutdown conditions as indicated by the various indicator lights. If the unit is down, check the system to determine the cause of the shutdown and repair or replace parts not working properly. If the storage tank is full make arrangements to have the tank emptied before attempting to restart the system. A troubleshooting guide for the equipment is provided in Section 7 of the NEPCCO Manual provided in Attachment 10. Additional trouble-shooting guidance is provided in Table 11-1 in Section 11 of this manual.

3. Inspect compound for water within the bermed areas. If water has collected within the equipment berm, check MV-6 in the sump below the manifold for proper working order. If rain water has collected in the secondary containment around the water storage tank (T-6), open the 4" diameter gate valve (GV-15) in the sump to drain.

4. Check the operation of pumps and motors (P-1 and P-2) by moving the appropriate switch on the control panel to the "hand" position. The motor in question should turn on. If not, check the NEPCCO Manual in Attachment 10 for troubleshooting guidance (Section 7) or for replacement parts (Section 3) as required. If the motors are working properly, be sure to return switches on the control panel to the "auto" position before leaving the compound.

5. Record tank levels, meter readings, and other information in top portion of Weekly O&M Data Sheet.

6. Shut LRV system off, clean the water strainer, clean/replace the bag filter, and change temperature chart recorder on oxidizer. Clean sludge from surface of oil/water separator and spray coalescing unit with water.

7. Restart LRV system on MV-1; record:
   - Appearance of water in manifold sight glass
   - T-2 water temperature
   - manifold vacuum pressure
   - PI-6
   - PI-7
   - GOM-3 pressure
   - TI-2 vapor stream temperature

8. Connect calibrated FID to stack sampling port without dilution probe or y-tube. Record concentration of stack gas.

9. Connect FID to BV-20 on oxidizer with dilution probe and y-tube and open BV-20.

10. Record other temperature and pressure readings on oxidizer.

11. Record FID reading from BV-20 and disconnect FID after closing BV-20.

12. If GOM-3 pressure was negative, close butterfly valve BF-2 on oxidizer one notch to achieve positive pressure. BE SURE TO RETURN THIS VALVE TO ITS ORIGINAL SETTING BEFORE DEPARTING SITE.

13. If pressure at GOM-3 is still not positive, open ball valve BV-13 slightly to relieve the vacuum caused by the dilution blower until pressure at GOM-3 is positive. BE SURE TO CLOSE BV-13 BEFORE DEPARTING SITE.

14. Connect FID with dilution probe and y-tube to GOM-2. Record range of concentration measured.

15. Record differential pressure across GOM-3. Close BV-13.

16. Observe condition of well piping and record appearance of water at well and well vacuum pressure. BE SURE THAT OXIDIZER IS OPERATING WITH A STABLE TEMPERATURE BEFORE LEAVING EQUIPMENT COMPOUND TO INSPECT WELL.

17. Switch LRV system to the next motor valve and repeat steps 3 through 12 until all wells have been monitored.

NOTE: IF OPERATING THE SYSTEM ON MANUAL, IMMEDIATELY SHUT OFF LRV SYSTEM IF THE OXIDIZER SHUTS DOWN.

8.2 MONTHLY OPERATION AND MAINTENANCE REQUIREMENTS

The following maintenance procedures should be performed on a monthly basis:

1. Collect a vapor effluent sample from GOM-2 or from BV-20 during recovery from each of the recovery wells. Forward samples to the laboratory for analysis for BTEX (EPA Method 5030/8020) and TPH (EPA Method 8015A). Use these concentrations to estimate product recovery in the vapor phase and to adjust vacuum settings to maximize product recovery while staying below the allowable air emission limits.

2. Collect a vapor sample from the thermal oxidation unit stack and forward the sample to the laboratory for analysis for BTEX (EPA Method 5030/8020) and TPH (EPA Method 8015A). Use this concentration to confirm the destruction efficiency of the thermal oxidizer.

3. Perform monthly maintenance on the transfer pumps (P-1 and P-2), the liquid ring vacuum pump (VP-1), and the thermal oxidation unit, and clean the oil/water separator (T-3), as outlined on the checklists provided in Attachment 2.

4. Check contact switches in the vault/sump for corrosion or bio-fouling. Clean the contact probes when needed.

5. Check all metal surfaces for exposed or rusted metal. Apply "Extend" rust treatment manufactured by Loctite Corporation, Ospho, or a similar rust treatment to rusting areas or thoroughly clean the area with sand paper or steel wool. Apply primer if needed and paint LRV system equipment with Rustoleum 2125 Deep Blue (spray can), which conforms to Rustoleum 0721 National Blue Industrial Enamel. Touch up thermal oxidizer with Ameron Amercoat 385 gray multi-purpose epoxy paint, and the natural gas piping with Ameron Amerlock 400 yellow high-solids epoxy coating.

8.3 PERIODIC OPERATIONS AND MAINTENANCE

The following maintenance procedures should be performed on a quarterly or as needed basis:

1. Maintain a log of the quantity of water transferred from the water storage tank (T-6) to the Industrial Wastewater Treatment Plant and product removed from the product storage tank (T-4). Use the log forms provided in Attachment 2.

2. Maintain a log indicating the recovery well that is connected to each motor valve, and the level of the drop tube in each recovery well. Use the recovery well status form provided in Attachment 2.

3. Check the operation of high level alarms by taking manual control of transfer pumps. The system should shut down and appropriate warning lights should activate including the beacon on top of the control panel. Reset the panel and return all switches to their normal "auto" position.

4. Collect a recovered groundwater sample from sample port SP-7 between the transfer pump (P-2) and the groundwater storage tank (T-6). Forward to the analytical laboratory for analysis for TPH (EPA Method 8015) and Volatile Organics (SW-846 Method 8240). Use the results to calculate mass recovery in the dissolved phase.

5. Skim product/water emulsion off the surface of the water in the water transfer tank (T-5).

6. Repaint the entire equipment skid and other painted metal surfaces on an annual basis or as needed.

7. Inspect PVC piping for deterioration, scaling, and biofouling. The clear tubing in the valve manifold may cloud up. This may be cleaned by unscrewing the top unions of the motor valves and removing the top section of the manifold enabling the technician to reach the clear pipe sections for cleaning. In extreme cases, the clear sections may require replacement.

8.4 FREEZE PROTECTION PROCEDURE

In the event that a hard freeze is expected, the following procedure should be followed to freeze protect the unit.

1. Turn off unit by turning the "Run" switch to the "off" position.

2. Shut off the circuit breakers in the control panel.

3. Drain the liquid ring vacuum pump (VP-1) by removing the brass plug on the bottom of the pump.

4. Drain transfer pump P-2 by removing the pipe plug in the bottom of the casing.

5. Open manifold valves GV-6 through GV-10.

6. Remove sediment filter and strainer YS-1 to drain piping. Reinstall filter and strainer.

7. Close BV-7 and open BV-13 to drain the line between the oil/water separator (T-3) and the water transfer tank (T-5).

8. Close BV-8 and open BV-14 to drain the line between the water transfer tank (T-5) and the water storage tank (T-6).

9. Drain the make-up water line by closing the water supply valve on the hose bib and opening the faucet.

10. Ensure BV-9 is closed and open GV-17, GV-18, and GV-15 to drain 4" diameter PVC lines from the water storage tank (T-6) and the containment area. Drain return water line from T-6 to the liquid ring vacuum pump by opening BV-24 after closing GV-16.

Before restarting the unit, ensure that all valves are in the correct operating position and all plugs are reinstalled onto the bottom of the pumps. Refer to the Monthly Maintenance checklist in Attachment 2 to determine normal operating position of valves.

8.5 SYSTEM INSPECTION CHECK SHEETS

The following system check sheets are provided in Attachment 2 for use during the following operations and maintenance events:

- Weekly O&M visits
- Monthly O&M visits
- Quarterly O&M visits
- Semi-annual O&M visits
- Annual O&M visits
- Recovery well status updates: includes record of recovery well attached to each motor valve and setting of the drop tube in each well
- Log form for transfer of product out of T-4 and water out of T-6
- Telephone alarm dial-out log form
- Unscheduled site visit form
- Sample collection documentation

8.6 CALIBRATION STANDARD PROCEDURE FOR FID

The operator must follow the calibration steps listed below when using the Flame Ionization Detector (FID)/Organic Vapor Meter (ThermoEnvironmental Model 680) with 10:1 Dilution Probe.

1. Ensure FID battery and hydrogen tank are fully charged.
2. Turn on meter and open hydrogen valve.
3. Allow FID to warm up for approximately ten to fifteen minutes.
4. Ensure response factor is 1.0. Initiate calibration mode on FID. Set FID to calibrate to 50 ppm and 950 ppm. Attach granulated carbon canister to FID intake for zero concentration gas.
5. Remove granulated carbon canister and attach 10:1 dilution probe. Connect 500 ppm methane calibration gas for low span calibration gas.
6. Connect 9500 ppm methane calibration gas for high span calibration gas.
7. Exit calibration mode. Recheck calibration using the two calibration gases.
8. Repeat calibration procedure until calibration is correct.

8.7 CALIBRATION PROCEDURE FOR DIGITAL MANOMETER (DWYER SERIES 475 MARK III)

The operator must follow the calibration steps listed below when using the digital manometer (Dwyer Series 475 Mark III). For other manometers, the operator should follow manufacturer recommendations for calibration.

1. Use the silver knob on top of the manometer to zero the readout. The manometer should not be connected to anything at the time.

9.0
REMOVAL OF STORED HYDROCARBON AND WATER

The separate phase hydrocarbon and the water must be removed periodically from the product storage tank (T-4) to avoid overfilling of the tanks. To empty the product tank (T-4), the vent may be removed and a one or two inch diameter drop tube inserted into the tank to vacuum out the contents. If water is present in the product tank it can be pumped back into the oil/water separator for reprocessing. If the automatic discharge on the T-6 tank fails, the water can be drained by using a vacuum truck. Do not drain T-6 below the 2000 gallon level so that a sufficient seal water supply is maintained.

10.0
TROUBLESHOOTING GUIDE

Table 4 is a trouble shooting guide for diagnosing common problems, additional trouble shooting can be found in Attachments 10 and 11.

TABLE 4
WATER TREATMENT SYSTEM TROUBLE SHOOTING GUIDE

CONDITION	PROBABLE CAUSE	REMEDY
LSHH-1 alarm - High level in T-1 tank (slow flash)	1. Level switch failure 2. Pump P-1 failure 3. Blockage in the line from T-1 to T-3	1. Clean and inspect level switch. 2. Check pump operation in manual mode. Drain tank and remove pump and inspect, replace damaged parts. Check for piping connection to P-1. Check for sediment in the tank. 3. Clean line. Check blockage points, i.e. valves and gauges.
LSHH-1 alarm - thermal oxidizer failure (fast flash)	Thermal oxidizer shut down	Check alarm faults on oxidizer panel. See Attachment 11 for oxidizer trouble shooting guide. Thermal oxidizer alarms are summarized below.
Thermal oxidizer high temperature alarm	High concentration of vapors entering the oxidizer.	Restart system and throttle the air flow to the system using GV-1 through GV-5 to control the air flow until the system is up to temperature. Adjust the vacuum on the well that caused the problem, reducing the vacuum slightly.
Thermal oxidizer power failure	Power outage	Restart system after power is restored.
Thermal oxidizer low gas pressure	Gas supply pressure fluctuation	Check with the base to confirm gas pressure. Restart system.
Thermal oxidizer process blower failure	Process blower not functioning properly	Inspect blower. Refer to equipment manual in Attachment 11 for blower details

TABLE 4 (Continued) WATER TREATMENT SYSTEM TROUBLE SHOOTING GUIDE		
CONDITION	**PROBABLE CAUSE**	**REMEDY**
LSHH-2 alarm Tank T-2 high level Alarm (Slow flash)	1. Level switch malfunction in the T-2 tank. 2. Solenoid valve malfunction	1. Inspect and clean the level switch. 2. Check operation of solenoid valves.
LSHH-2 alarm (fast flash) The circuit breaker on the LRVP tripped.	Scaling in the pump or too high of water flow for the vacuum conditions.	Refer to Attachment 10 Section 2. Clean the scale or adjust the flow rate. Check the operating amps on the pump after cleaning. Check sequestering chemical supply system.
High level alarm LSHH-3, high level in product tank T-4	1. The product tank is full of water. 2. The product tank is full of product.	1. If the product tank is filling with water, the oil/water separator may not be working properly. Clean the oil/water separator. 2. The product tank is full, make arrangements to empty the tank.
High level alarm LSHH-4, high level in water tank T-5	1. Level switch malfunction in the T-5 tank. 2. Transfer pump P-2 is not operating properly. 3. Line is blocked	1. Check and clean level switch. 2. Check switch, make sure it is in auto position. Check pump for proper operation. 3. Check line for blockage including valve position.
High level alarm LSHH-5, high level in water tank T-6	1. Level switch malfunction in the T-6 tank. 2. Transfer pump P-6 is not operating properly. 3. Line is blocked	1. Check and clean level switch 2. Check switch, make sure it is in auto position. Check pump for proper operation. 3. Check line for blockage including valve position.

11.0
HEALTH AND SAFETY

11.1 RISK

O&M activities are assessed as low risk. The potential for chemical and biological exposures of any significance by any route of entry is considered low as long as personnel follow: (1) approved start-up and shut-down procedures during operations as documented in this O&M Manual, and guidelines listed in each of the vendor equipment technical specifications during routine maintenance and service; (2) always assess energy control requirements and verify zero energy state prior to opening any part of the system for maintenance; and (3) upgrade Personal Protective Equipment (PPE) from Level D to Modified Level D for selected tasks to include groundwater sampling; handling scale prevention and dispersant chemicals; skimming product/water emulsion in water transfer tank; and during hookups for removal of stored hydrocarbon and water from T-4 and T-6.

11.2 PHYSICAL HAZARDS

Other physical hazards include pressurized liquid in pressure filter vessels; flame arrester weight; and general slips, trips and falls.

11.3 HOUSEKEEPING

Good housekeeping should be maintained at all times at this facility. Non-essential storage is not permitted in or around the processing unit. No smoking, eating, chewing or drinking is permitted at this facility. All valve indication tags, pipe labeling and tank/container markings should be maintained intact and clean.

11.4 TRAINING

All O&M personnel are required to receive site-specific training prior to entering the site or the commencement of work. Topics to be covered include site and work overview; general safety rules and procedures; hazard communication; first aid and medical responsibilities; emergency response and contingency planning; safety and health hazards present on site and anticipated during O&M work; PPE requirements; safe work practices; engineering controls; decontamination procedures; spill containment plan; and energy control.

All O&M personnel are required to be 24-hour OSHA HAZWOPER trained per 29 CFR 1910.120(e). All operations and maintenance personnel are required to be covered under a medical surveillance program as described in Section 11.9. All personnel required to classify, mark, select packaging, inspect, load and transport hazardous materials are required to be trained to 49 CFR 172 Subpart H. Copies of all training records should be available for review.

11.5 PERSONAL PROTECTIVE EQUIPMENT (PPE)

As a minimum, all O&M personnel are required to wear leather work boots and safety glasses with side shields and have available leather work gloves. In addition, hardhats are required when bump protection is necessary such as servicing system components near transfer lines. This clothing ensemble is referred to as Level D PPE.

Level D work clothing is required to provide protection for arms, legs, and feet from cuts and abrasions. Full length slacks (no holes permitted) are required. No loose fitting clothing, sleeveless clothing, tank tops, bare stomach clothing, or sweatpants are permitted. Shirts are required to be long enough to be tucked in. As a minimum, T-shirts are required to have a three inch sleeve.

PPE requirements for system monitoring and the majority of the scheduled maintenance tasks can be completed in Level D. For groundwater sampling, modify the Level D PPE to include the addition of disposable latex or equivalent gloves. In addition, use disposable rubber or nitrile gloves when replacing filter bags and/or cartridges and when making connections to pump-down T-4 and T-6.

Modified Level D PPE is also required when working with the scale prevention and dispersant chemicals, NALCO 8357 and DYNACOOL 8301-D. This modification includes rubber gloves, indirect venting chemical goggles, and rubber apron.

When servicing the pressure filter vessels, follow the cautions and warnings listed in the vendor data found in Attachment 6. Always wear a full face shield when disconnecting system components until zero energy state for process fluids has been confirmed.

The O&M personnel are required to have available, when working on site, one 10 lb multi-purpose ABC fire extinguisher complying with National Fire Protection Association (NFPA) 10 with a minimum rating of 4A:60B:C; first aid kit; and one personal eyewash station complying with American National Standards Institute (ANSI) Z358.1-1990. When working with scale prevention and dispersant chemicals, the O&M personnel are required to have available at the worksite one eyewash/drench, minimal 10 gallon capacity complying with ANSI Z358.1-1990.

11.6 ACTIVITY HAZARDS ANALYSIS (AHA)

Activity Hazards Analysis (AHA) worksheets have been prepared for each major O&M task and are attached as Table 5. Each activity should be reviewed by field supervision or the O&M technicians prior to starting work to determine if the prepared AHA adequately addresses the planned activity. If the prepared AHA requires revision or a new task is identified, additional hazard analysis should be prepared as needed.

11.7 HAZARD COMMUNICATION

All personnel are required to complete hazard communication as part of the site-specific training pursuant to 29 CFR 1910.1200 regarding all hazardous chemicals to which they may be potentially exposed. When new chemicals are introduced into the workplace to support work completion, the Job Supervisor is responsible for reviewing the Material Safety Data Sheets (MSDS); identifying training needs for affected personnel; arranging for and completing this training for affected workers, and transmitting a copy of the MSDS(s) to the designated personnel. One set of MSDS is required to be maintained at the work site as part of this O&M Manual. Refer to Attachment 11 and 12.

11.8 ACCIDENT/INCIDENT REPORTING

All accidents, and incidents are required to be promptly reported to the Job Supervisor and a written report is required to be provided to the Contracting Authority and/or Owner within 24 hours of the incident. At a minimum, the Job Supervisor is required to prepare a memo describing the incident including: injuries; equipment damage and/or property damage; how the incident was managed; and corrective action. Attachments to this memo should include the following where applicable: a) employer's first report of injury form; b) Supervisor's Accident Investigation Report form or OSHA Supplemental 101 Form; c) Contractor Significant Incident Report (CSIR) for equipment damage greater than $1000.00 ; d) Any records provided by the medical service provider to include emergency room report, examining physicians designation of work restriction, and examining physician's work release. The Job Supervisor should verbally advise the Contracting Authority and/or Owner of all first aid cases as soon as possible. The O&M Contractor is required to maintain a first aid log sheet listing at a minimum, affected person, treatment, and date.

11.9 MEDICAL SURVEILLANCE PROGRAM

All O&M personnel are required to participate in a **Medical Surveillance Program** as described in 29 CFR 1910.120 (f). The Medical Surveillance Program consists of a baseline or initial examination, an annual medical examination, a termination examination, and episodic medical examination as necessary. No additional medical surveillance requirements or biological monitoring beyond what is specified in the OSHA regulation are necessary at this time. The examining physician's medical clearance forms which state the employee's ability to work with hazardous materials and use respiratory protection are to be available for review prior to beginning work.

11.10 EMERGENCY PHONE NUMBERS

The O&M Contractor is required to post emergency phone numbers when working at this site and be cognizant of the location of the nearest emergency communications equipment. The facilities' on site emergency response number is **911, or 512-939-2424 Ambulance, or 512-939-3333 Fire**. The on-site O&M Contractor personnel should verify and test the emergency phone number if the primary communication method will be a cellular phone.

11.11 ENERGY CONTROL PLAN

The **Energy Control Plan (Lockout/Tagout)** for this subject facility is described in the following paragraphs. The O&M Contractor is required to provide all necessary locks and tags and complete and verify zero energy state prior to servicing components requiring energy control. Components requiring energy control and verification of zero energy state prior to servicing include the following: 1) all pumps; 2) all filters; 3) motor assisted valves; 4) FSI Filter Housing (lockout and tagout power supply to pumps and verify no internal pressure; and 5) Thermal Oxidizer. The natural gas supply to the Thermal Oxidizer is also required to be lockout/tagout during major servicing or as specified in vendor data.

A local disconnect switch for incoming electrical power to the treatment system is located on the main transformer adjacent to the equipment pad. Release of pressurized fluid energy should be completed prior to servicing FSI Filter Housing and prior to disconnecting of process piping. The FSI Filter Housing can be drained at local sampling port. Process piping can be drained back to the wells or at local sample ports.

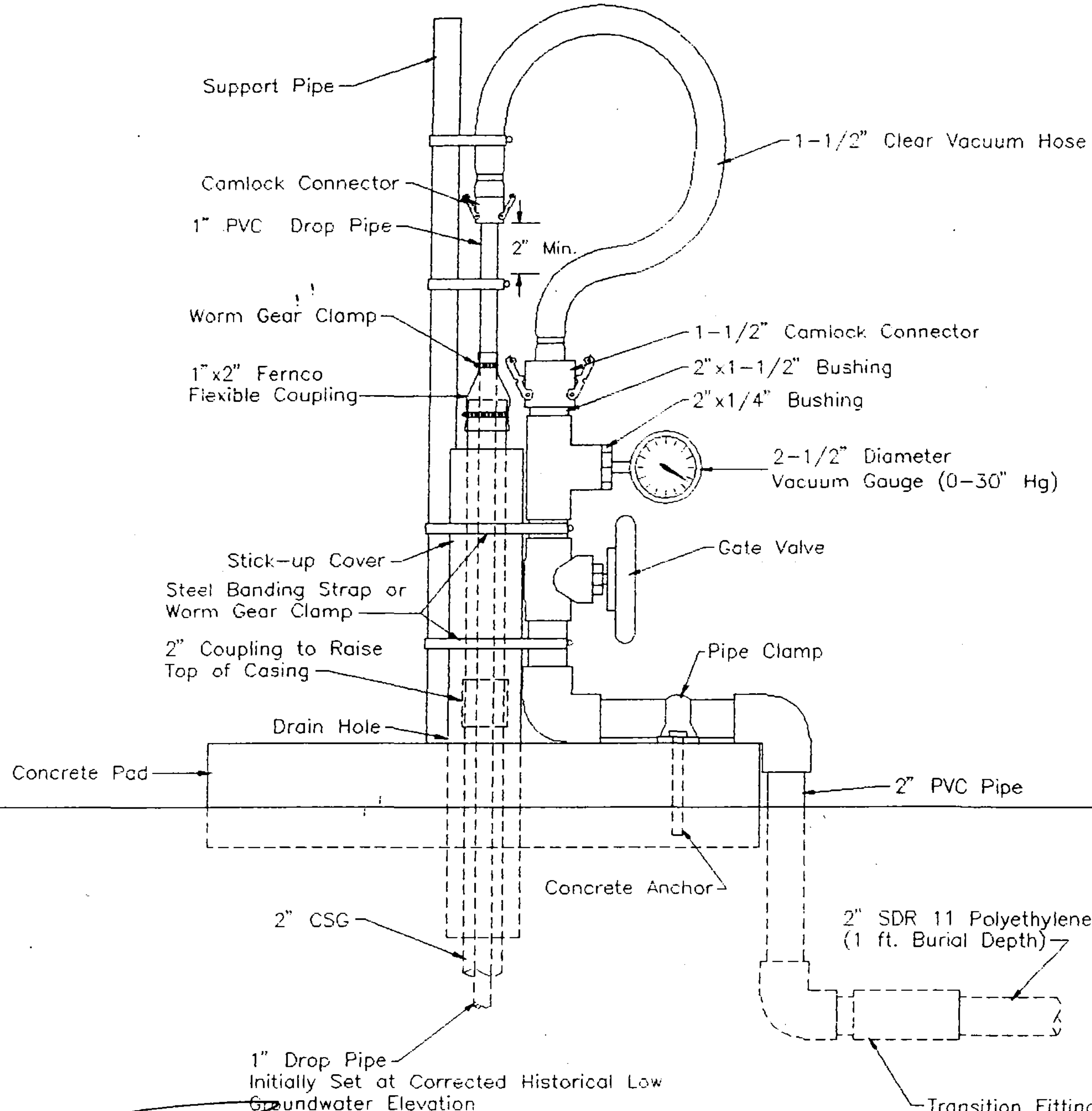
TABLE 5 ACTIVITY HAZARD ANALYSIS (AHA)			
Activity: Start-up Testing of Facility		Analyzed By/Date: Frank J. Petrik 8/29/97	Reviewed By/Date:
1.0 Principal Steps	Potential Hazards	Recommended Controls	
1.1 Pressure testing of influent and effluent piping; instrumentation checks; prime mover checks; and flow system.	1.1a. Struck by and struck against physical objects during checkout including ergonomic. Slips, trips and falls.	1.1a. Contractor shall be cognizant of emergency communication equipment and emergency protocol. Always use correct hand and power tools for the job and maintain good housekeeping practices. Use approved ladders and placement methods when working from heights and 100% fall protection for elevated work over 6 foot. Insure safe lifting and handling procedures. Use proper lifting techniques and mechanize where possible.	
	1.1b. Electrical and mechanical energy.	1.1b. Perform energy control per O&M manual and vendor supplied data.	
	1.1c. Contact by inhalation, direct contact or ingestion of chemical and/or biological contaminants.	1.1c. Level D PPE anticipated for majority of tasks. Upgrade to Modified Level D where contact with contaminated groundwater is possible and when handling water treatment chemicals. Use chemical resistant gloves when making connections to pump-down tanks. Use good hygiene practices including washing hands with soap and water after working at the site. First aid kit, eyewash, fire extinguisher, spill pads available, and emergency communications identified. No smoking, eating, or drinking is permitted at the treatment facility.	
1.3 Equipment to be Used	Inspection Requirements	Training Requirements	
1.4 Handtools, instruments and pressure pump.	Daily, prior to use per manufacturer's recommendation.	OSHA 1910.120 twenty four hour training and site specific.	

TABLE 5 (Continued) ACTIVITY HAZARD ANALYSIS (AHA)		
Activity: Operation and System Monitoring	Analyzed By/Date: Frank J. Petrik 8/29/97	Reviewed By/Date:

2.0 Principal Steps	Potential Hazards	Recommended Controls
2.1. Complete valve line-ups, start-up system, inspect system, check water levels and monitor flow rates.	Struck by and struck against physical objects. Slip, trips and falls. Contact by inhalation, direct contact or ingestion of chemical and biological contaminants.	Use correct hand tools if necessary for job and maintain good housekeeping practices. Level D PPE anticipated for majority of tasks. Walk facility down, inspect all components for integrity and evidence of leaks in system, initiate repair where necessary or shut system down. Use good hygiene practices including washing hands with soap and water after working at the site. First aid kit, eyewash, fire extinguisher, and spill pads available, and emergency communications identified. No smoking, eating, or drinking is permitted at the treatment facility.
2.4 Equipment to be Used	**Inspection Requirements**	**Training Requirements**
2.5 Handtools and instruments.	Pre-operational as required in O&M Manual.	OSHA 1910.120 twenty four hour training and site specific.

TABLE 5 (Continued) ACTIVITY HAZARD ANALYSIS (AHA)		
Activity: System Service and Maintenance	Analyzed By/Date: Frank J. Petrik 8/29/97	Reviewed By/Date:
3.0 Principal Steps	**Potential Hazards**	**Recommended Controls**
3.1 Refer to preventive maintenance schedule.	Electrical and mechanical energy.	Complete energy control per O&M Manual and vendor supplied data. No hot work without permit.
	Contact by inhalation, direct contact or ingestion of chemical and biological contaminants.	Level D PPE anticipated for most tasks. Upgrade to Modified Level D if contact with chemical agents and wastewater possible and for those tasks listed in the Health and Safety section of O&M Manual. Review all MSDS Sheets for chemicals prior to use. Visually inspect area and equipment for evidence of chemical/biological contaminants. Preplan all lifts. Use approved ladders and placement methods when working from heights. Insure safe lifting and handling procedures. Use proper lifting techniques and mechanize where possible. Use good hygiene practices including washing hands with soap and water after working at the site. First aid kit, eyewash, fire extinguisher, and spill pads available, and emergency communications identified. No smoking, eating, or drinking is permitted at the treatment facility.
3.3 Equipment to be Used	**Inspection Requirements**	**Training Requirements**
3.4 Handtools, cleaning solutions, oil and greases	Before use per manufacturer's data.	OSHA 1910.120 twenty four hour training and site specific.

TABLE 5 (Continued) ACTIVITY HAZARD ANALYSIS (AHA)			
Activity: Sampling and Waste Management		Analyzed By/Date: Frank J. Petrik 8/29/97	Reviewed By/Date:
4.0 Principal Steps	Potential Hazards	Recommended Controls	
4.1 Obtain effluent water samples. 4.2 Obtain vapor emissions samples. 4.3 Replace sediment filters. Inspect and clean Hi-Hi probe in product storage tank. Clean oil/water separator.	4.1 Direct contact with non potable water. 4.2 Direct contact with liquid blow by and inhalation of vapors. 4.3 Direct contact with sludge material (chemical and biological hazard).	4.1 Level D PPE, Wear disposable latex gloves. Use approved sampling container. Use tubing to connect to sample port, fasten if necessary per procedure. 4.2 Level D PPE, wear disposable latex gloves. Do not stand in direct line with vent discharge line. Sample per procedure. 4.3 Level D PPE, Wear disposable nitrile gloves or equivalent. Use approved containers. Conduct FID scans prior to removing equipment if conditions warrant. Complete energy control. Open up and allow oil/water separator to vent prior to cleaning. Preplan transport of waste material and insure container is properly labeled. Use good hygiene practices including washing hands with soap and water after working at the site. First aid kit, eyewash, fire extinguisher, and spill pads available, and emergency communications identified. No smoking, eating, or drinking is permitted at the treatment facility.	
4.3 Equipment to be Used	Inspection Requirements	Training Requirements	
4.4 Handtools, cleaning equipment, and sampling containers.	Prior to use per manufacturer's recommendation.	OSHA 1910.120 twenty four hour training and site specific. DOT 181 training for person supervising shipment of samples and collected product.	



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OPERATIONS AND MAINTENANCE MANUAL
MULTIPHASE RECOVERY SYSTEM
FUEL FARM 216
NAS CORPUS CHRISTI, TEXAS

COMPONENTS LIST

These items have been provided in addition to the items listed in Section 1 of the NEPCCO Groundwater Remediation System Manual (Attachment 10) and the items listed in Section XI of the ThermTech manual (Attachment 11).

P&ID LABEL	DESCRIPTION & SPECIFICATIONS	MODEL NUMBER
FQ-2	Make-up water flow totalizer, 3/4" diameter	
LSL/LSH-5	Differential level switch in T-2	Nohken Model FQ-6
GOM-2	Gas Orifice Meter, 2"	Eclipse SBO-448
GOM-3	Gas Orifice Meter, 1"	Eclipse SBO-X-1
TI-1	Temperature indicator on T-2	
TI-2	Temperature indicator on vapor effluent line	
T-7	Condensate collector/ moisture separator for vapor effluent, 20 gallon	
SP-8	No longer in use	
SP-9	No longer in use	
SP-10	Sample port with ball valve on vapor bypass to atmosphere	
BV-10, BV-11, BV-24	Ball valves on drain lines, 0.5"	
BV-9	Ball valve on T-6, 4" PVC	
BV-12	Ball valve, 1", on T-7 condensate drain	
BV-13	Ball valve, 2" PVC, vapor bypass from T-7 to atmosphere	

P&ID LABEL	DESCRIPTION & SPECIFICATIONS	MODEL NUMBER
GV-15	Gate valve in sump from T-6 secondary containment, 4"	
F-1	Bag filter, stainless steel	Filter Specialists Inc. Model BFNP-12-6-304-2
	Filter bags, 100 micron, nylon monofilament mesh	FSI NMO-100-P2P
BV-22	Ball valve, 2" PVC, on suction line from sump	
BV-23	Ball valve, 2" PVC, on SV-1 ambient intake	
BV-25	Ball valve, 0.5", on T-6 sight glass	
CV-5	Check valve, 2" PVC, before GOM-1	
FI/FC-3	Adjustable flow indicator prior to LRV pump, range 0.4 - 4 gpm, with brass valve	Ratemaster RMC-143-BV
GV-16, GV-17, GV-18	Gate valves, 4", leading from T-6 or T-6 containment	
GV-19	Gate valve, 1", for natural gas supply	
GV-20	Gate valve, 2", for base water supply	
SV-3	Solenoid valve, 1", normally closed, for seal water from T-6 to LRV pump	
SV-4	Solenoid valve, 1", normally open, for seal water from T-2 to LRV pump	
CV-4	Check valve, 1" PVC, before SV-3	
LSL-6, LSH-6, LSHH-7	Float switches in T-7	

P&ID LABEL	DESCRIPTION & SPECIFICATIONS	MODEL NUMBER
P-3	Positive displacement pump for condensate drain in T-7, bolt-on with NEMA 56C frame motor, brass body	PROCON Series 4
P-4, P-5	Chemical metering pumps for scale inhibitor and dispersant chemicals	Pulsafeeder P01200
CV-6	Check valve, 1", after P-3	
GLV-1	Globe valve, 1", after P-3	

OPERATIONS AND MAINTENANCE MANUAL
MULTIPHASE RECOVERY SYSTEM
FUEL FARM 216
NAS CORPUS CHRISTI, TEXAS

ATTACHMENT 2

O&M DATA FORMS

Telephone Alarm Log
Hydrocarbon Recovery System
NAS Corpus Christi - Fuel Farm 216

Week of Telephone Log ____________________

Date	Time	Person taking call	Person responding to site	Date arrived on site	Time arrived on site	Time spent on site (hours)	Action taken

Unscheduled Site Visit
Hydrocarbon Recovery System
NAS Corpus Christi - Fuel Farm 216

Date	
Time on site	
Personnel on site	
Status of system	
Cause of shut down/reason for visit	
Action taken	
Additional items needing action	
Time departed site	
Status of system	

WEEKLY CONTROL PANEL REPORTING FORM
MULTI PHASE EXTRACTION SYSTEM

	Initial Status			Final Status (If changed)		
LRV System Operation	Off	On		Off	On	
Thermal Oxidizer Operation	Off	On		Off	On	
LRV Off / Run switch position	Off	Run		Off	Run	
MV-1 Switch position	Hand	Off	Auto	Hand	Off	Auto
MV-2 Switch position	Hand	Off	Auto	Hand	Off	Auto
MV-3 Switch position	Hand	Off	Auto	Hand	Off	Auto
MV-4 Switch position	Hand	Off	Auto	Hand	Off	Auto
MV-5 Switch position	Hand	Off	Auto	Hand	Off	Auto
Vacuum Pump VP-1	Hand	Off	Auto	Hand	Off	Auto
Transfer Pump P-1	Hand	Off	Auto	Hand	Off	Auto
Transfer Pump P-2	Hand	Off	Auto	Hand	Off	Auto
LSHH-1 or Thermal Oxidizer	Off	On		Off	On	
LSHH-2 or LRV Overload	Off	On		Off	On	
LSHH-3	Off	On		Off	On	
LSHH-4	Off	On		Off	On	
LSHH-5 or LSHH-6	Off	On		Off	On	

Notes:

Weekly C. .M Data Sheet
Hydrocarbon Recovery System
NAS Corpus Christi - Tank Farm 216

Page _____ of _____

Date:________________ Time on site:__________ System on or off:__________ Temperature:______°F

Time off site:__________ System on or off:__________ Weather:______________________________

Tank gauges:

550 gal water tank (T-5):__________gal. 5000 gal water tank (T-6):__________gal. Product tank (T-4): _____in. ______gal. product

_____in. ______gal. water

Other readings:

P-1 discharge pressure (PI-8).__________psi (normal range 50-70 psi)

P-2 discharge pressure (PI-9):__________psi (normal range 23-27 psi)

P-3 discharge pressure (PI-10):__________psi (normal range 30-40 psi)

P-6 discharge pressure (PI-11):__________psi (normal range 20-25 psi)

Adj.water flow meter (FI/FC-2)________gpm (normal range 1.0-1.5 gpm)

Adj.water flow meter (FI/FC-3)________gpm (normal range 1.5-3.5 gpm)

Thermal Oxidizer Operating Hours ___________

Y-strainer at LRV (YS-2): _____checked _____cleaned

Bag filter: _____checked ____ cleaned ____replaced

Paint Touched up: ________

Sheen present on water sampled at BV-11: _____yes _____no

pH of water sampled at BV-11: ________ (normal range 6.5-7.5)

Discharge water flow totalizer (FQ-1):_____________gal.

Fresh water flow totalizer (FQ-2):________________gal.

Sediment filter at T-7: _____ checked ____cleaned ____replaced

Drain vapor line entering thermal oxidizer:________

Check chemical pump operation: P-4______ P-5________

Monitor flow into LRV from T-6 (ensure T-2 fills): ______

Natural Gas Meter: ____________ cubic feet

Sump: water level: _____ feet; ____cleaned out

Inspect for rust and corrosion: _______

Location of corrosion: ________________________

Inspect switches for fouling/scale: ____ Scale location __________

Replace chart recorder paper

Time	Well	Motor Valve	Appearance of water in manifold sight glass	Condition of well piping/ appearance of water at well	T-2 water temp. (°F) TI-1	Vacuum Pressure (in. Hg)				Differential Pressure (in. H_2O)		Pressure of Vapor Stream (in. H_2O)		Vapor Stream Temp. (°F) TI-2	Effluent Conc. FID (ppm) GOM-2	Sample ID
						well	manif	PI-6	PI-7	GOM-3 1" dia. SBO X-1	GOM-2 2" dia. SBO-448	GOM-3 1" dia. SBO X-1	GOM-2 2" dia. SBO 448			

Comments:____

____

____

Signature

Revised 12/1/97

NAS Cor, Christi - Tank Farm 216

Page _____ of _____
Date ____________

Time	Well	Motor Valve	Appearance of water in manifold sight glass	Condition of well piping/ appearance of water at well	T-2 water temp. (°F) TI-1	Vacuum Pressure (in. Hg)				Differential Pressure (in. H_2O)		Pressure of Vapor Stream (in. H_2O)		Vapor Stream Temp. (°F) TI-2	Effluent Conc. FID (ppm) GOM-2	Sample ID
						well	manif	PI-6	PI-7	GOM-3 1" dia. SBO X-1	GOM-2 2" dia. SBO-448	GOM-3 1" dia. SBO X-1	GOM-2 2" dia. SBO 448			

NAS Corpus Christi - Tank Farm 216
Thermal Oxidation Unit

Page _____ of _____
Date _____________

Time	Well	Burner Temperature (degrees F)	Stack Temperature (degrees F)	Differential Pressure Diluted Process Air FI-309 (inches H_2O)	Natural Gas Pressure PSH-106 (inches H_2O)	Vacuum on Process Air PI-302 (inches H_2O)	Pressure on Process Air PI-301 (inches H_2O)	Differential Pressure on Natural Gas FI-107 (inches H_2O)	Differential Pressure on Burner PDI-501 (inches H_2O)	Diluted Process Air Temperature TI-307 (degrees F)	FID Concentration of Diluted Process Air BV-20 (ppm)	FID Concentration of Stack Effluent S-1007 (ppm)

MONTHLY MAINTENANCE/INSPECTION CHECKLIST NAS CORPUS CHRISTI		
Date	**Inspected by:**	
	Activity Summary	**Action/results**
Submersible Transfer Pump P-1	Operating Amps (9 amps normally)	
	Pump Operating	
	Pump Inspected	
	Intake Cleaned	
Transfer Pump P-2	Operating Amps (4 amps normally)	
	Motor Coupling Checked	
	Pump operating	
	Inspect shaft seal for leaks	
Liquid Ring Vacuum Pump VP-1	Operating Amps (22 amps normally)	
	Dilution air filter cleaned	
	Inspect seal water source operational	
	Sediment filter cartridge replaced	

MONTHLY MAINTENANCE/INSPECTION CHECKLIST NAS CORPUS CHRISTI		
Date	**Inspected by:**	
	Activity Summary	**Action/results**
FQ-1	Inspect meter operation	
FQ-2	Inspect meter operation	
YS-1 Strainer	Inspect strainer	
	Clean strainer	
Alarm testing, manually test each alarm	T-1 Moisture separator tank LSHH -1	
	T-2 Seal water tank LSHH-2	
	T-4 Product tank LSHH -3	
	T-5 500 gal. Water tank LSHH-4	
	T-6 5000 gal, water tank LSHH-5	
	Thermal oxidizer	
	LRV Motor Thermal Overload Cicuit Breaker	
	Sump LSHH-6	
Well Fernco Flexible fitting	Inspect for signs of wear.	
	Replaced	

MONTHLY MAINTENANCE/INSPECTION CHECKLIST NAS CORPUS CHRISTI			
Date	**Inspected by:**		
Activity Summary			**Action/results**
Wire connections	Inspect all wire connections for loose or dirty connections.		
Valves - Manually operate valves to ensure smooth operation NO = normally open NC = normally closed	GV-1 (NO)	GV-8 (NC)	BV-2 (NC)
	GV-2 (NO)	GV-9 (NC)	BV-3 (NC)
	GV-3 (NO)	GV-10 (NC)	BV-4 (NC)
	GV-4 (NO)	GV-15 (NC)	BV-5 (NO)
	GV-5 (NO)	GV-16 (NO)	BV-6 (NO)
	GV-6 (NC)	GV-18 (NC)	BV-7 (NO)
	GV-7 (NC)	BV-1 (NC)	BV-8 (NO)
Oil/Water Separator	Check sludge build-up in sludge chamber		
	Check skimmer assembly		
	Check trough and discharge opening for debris accumulation		
	Inspect coalescing tubes		

MONTHLY MAINTENANCE/INSPECTION CHECKLIST NAS CORPUS CHRISTI		
Date:	**Inspected by:**	
	Activity Summary	**Action/results**
Thermal Oxidizer	Inspect all connections for leaks.	
	Test light bulbs on control panel. Replace as necessary.	
	Inspect filter elements. Clean or replace as needed.	
	Remove flame arrestor drain plugs and drain liquid.	

NAS CORPUS CHRISTI PRODUCT RECOVERY SYSTEM	**Procedure Type** **MONTHLY SUMMARY LOG OF SITE ACTIVITIES**

Inspector Signature ______________________________

Date ______________

Page ___ of ___

date	Summary of activities

Note: Include a summary of activities, problems solutions Refer to detailed logs, Example Performed maintenance, collected samples,

FORM TV10
THERMAL OXIDIZER REPORT

Monthly Period From: ___/____/___ To: ___/____/___

Command/Organization ________ Location ______________________________

At any time during the reporting period has the TPH concentrations exceeded 110,000 ppm? Yes __ No __

At any time during the reporting period has the reportable quantity of any air contaminate compounds and specifically listed mixtures been exceeded? Yes __ No __

At any time during the reporting period has the destruction efficiency of any air contaminate compounds and specifically listed mixtures been below 97.5 %? Yes __ No __

Are manufacturer's operating instructions posted at the site? Yes X No __

At any time during the reporting period has the operational criteria been below 1,400 degrees F and a minimal gas retention time of 0.5 seconds? Yes __ No __

At any time during the reporting period has the opacity been less than or equal to 5 % in any 5 minute period for all visible emissions, except uncombined water? Yes __ No __

During the reporting period how much natural gas was used?

January	____________	mcf	**July**	____________	mcf
February	____________	mcf	**August**	____________	mcf
March	____________	mcf	**September**	____________	mcf
April	____________	mcf	**October**	____________	mcf
May	____________	mcf	**November**	____________	mcf
June	____________	mcf	**December**	____________	mcf

YEARLY TOTAL = ____________ mcf

Upon completion, provide a copy of this MSDS form and a copy of the manufacturer's MSDS to the Air Quality Program, Environmental Compliance Division of Navy Public Works Code 189, Build. 19.

TOTAL P.01

QUARTERLY MAINTENANCE/INSPECTION CHECKLIST NAS CORPUS CHRISTI	
Date:	**Inspected by:**
Activity Summary	**Action/results**
Ratemaster Flow Meter Disassemble, inspect, clean, and reassemble	
Motor valves Disassemble and inspect. Replace worn parts	
Well level measurement System shut down for 24 hours, well measurement, system restart. RECORD PRODUCT AND WATER LEVELS FOR 5 RECOVERY WELLS	MW-13
	MW-20
	MW-21
	MW-26
	MW-29

SEMIANNUAL MAINTENANCE/INSPECTION CHECKLIST NAS CORPUS CHRISTI	
Date:	**Inspected by:**
Activity Summary	**Action/results**
Moisture Separator Drain and clean interior of tank	
Transfer Pump Grease motor bearings.	
Thermal Oxidizer Inspect flame monitoring device.	
Thermal Oxidizer Check/replace grease or oil in blowers/grease motors and bearing pillow blocks.	
Thermal Oxidizer Oil linkage swivels on control valves.	

ANNUAL MAINTENANCE/INSPECTION CHECKLIST NAS CORPUS CHRISTI		
Date:	**Inspected by:**	
	Activity Summary	**Action/results**
Thermal Oxidizer	Inspect ceramic fiber insulation for tearing, shrinking, or movement. Replace if needed.	

Field Sampling Data Sheet
Operations and Maintenance - Groundwater Treatment Facility
NAS Corpus Christi

Date:	Weather Conditions:

Sample Collection Information, if completed

Type	Sample I.D.	Time Collected	Analyses	Date Shipped
off tank liquid				
vapor emissions inline				
vapor emissions inline				
vapor emissions inline				
vapor emissions inline				
vapor emissions inline				
vapor emissions - after treatment				
sludge sample				

Notes/Unusual Observations:

Names:	Signatures:	Company:

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MULTIPHASE RECOVERY SYSTEM
FUEL FARM 216
NAS CORPUS CHRISTI, TEXAS

RECOVERED GROUNDWATER - CUMULATIVE TOTAL

DATE	FLOW TOTALIZER READING FQ-1 (gallons)	ACTUAL TOTAL WATER REMOVED FROM T-6: FQ-1 + 4450 (gallons)	QUANTITY WATER TRANSFERRED OUT OF T-6 (gallons)	CUMULATIVE QUANTITY TRANSFERRED OUT OF T-6 (gallons)

MULTIPHASE RECOVERY SYSTEM
FUEL FARM 216
NAS CORPUS CHRISTI, TEXAS

RECOVERED PHASE SEPARATE HYDROCARBON - CUMULATIVE TOTAL

DATE	QUANTITY TRANSFERRED OUT OF T-4 (gallons)	CUMULATIVE QUANTITY TRANSFERRED OUT OF T-6 (gallons)

MULTIPHASE RECOVERY SYSTEM
FUEL FARM 216
NAS CORPUS CHRISTI, TEXAS

RECOVERY WELL STATUS FORM

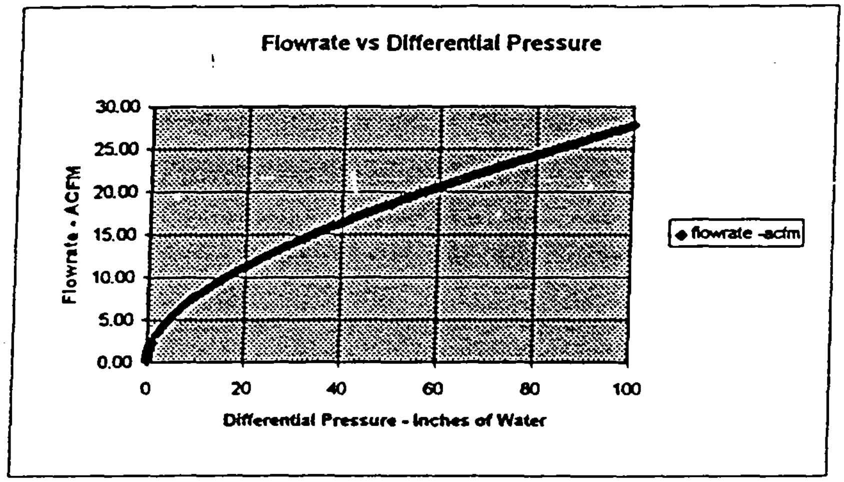
DATE: ______________________

MOTOR VALVE	RECOVERY WELL	LEVEL OF DROP TUBE IN WELL (FEET BELOW TOP OF CASING)
MV-1		
MV-2		
MV-3		
MV-4		
MV-5		

COMMENTS: ____

Procedures for Calculating Emissions of Petroleum Hydrocarbons from Corpus Christi NAS Liquid Ring Pump Recovery System

Table below is for Eclipse Dungs 1" SBO - X - 1 Orifce Plate
Not valid for other flow measurement devices



1. Determine ppmv of petroleum hydrocarbon using a "Century OVA 128 GC" or similar instrument.

(1) ________ ppmv This is TPH, for Benzene use last laboratory analysis, benzene/TPH to get % benzene, multiply ppmv X % benzene

2. Record differential and static pressures and line temperature.

(2) ________ differential pressure - inches of water

(2.1) ________ static pressure - inches of water

Static and differential pressures should be close, if not contact project manager

(2.2) ________ line temperature - degrees fahrenheit

Calculations assume 100 Degrees, if not close contact project manager

3. Convert ppm to mg/m^3.

ppmv * molecular weight / 24 = mg/m^3

MW TPH = 114
MW Benzene = 78.11

(1) ________ X MW ________ / 24 = ________ mg/m^3

4. From chart record acfm.

(4) ________ acfm

5. Calculate lbs/hr

acfm * mg/m^3 * 0.000003972 = lbs/hr

(4) ________ X (3) ________ X 0.000003972 = ________ lbs/hr

OPERATIONS AND MAINTENANCE MANUAL
MULTIPHASE RECOVERY SYSTEM
FUEL FARM 216
NAS CORPUS CHRISTI, TEXAS

ATTACHMENT 3

ORIFICE PLATE DOCUMENTATION

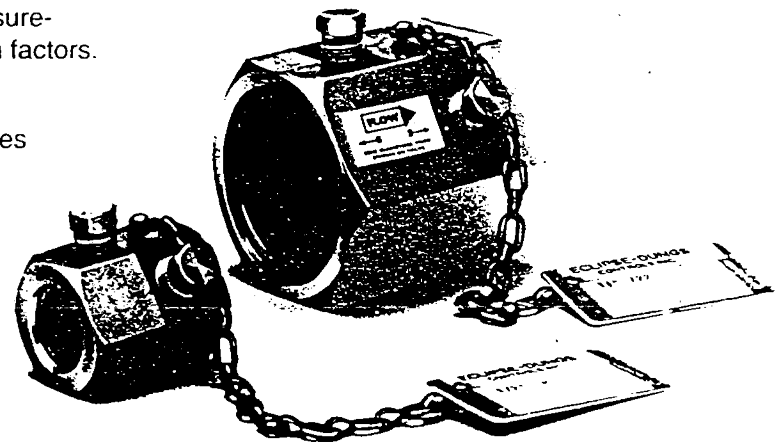
Gas Orifice Meters

I-460
Bulletin
12/92

Screwed Brass Orifices (SBO)—1/2" thru 2-1/2"; rated 250 PSI

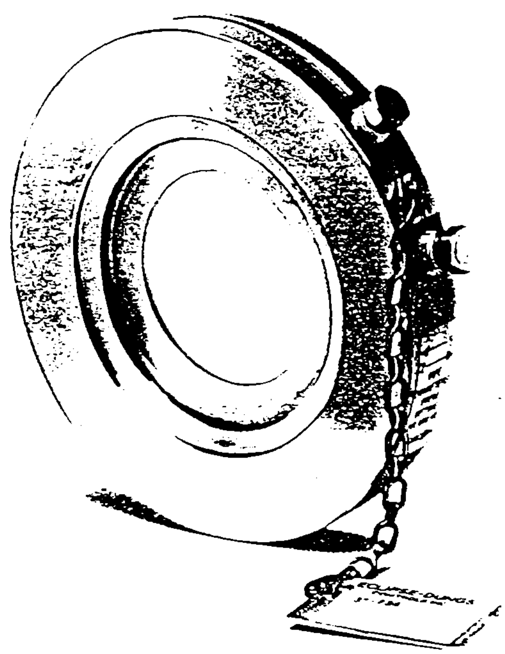
- Low cost metering device permits accurate setting of burner air & gas flow for optimum efficiency.
- ±1% accuracy depending on location, measurement accuracy and proper use of correction factors.
- One piece machined brass construction.
- Includes brass hex-head screws to plug holes when measurements are not being taken.
- Metal tag chained to valve clearly shows orifice pipe size and model number.

Pipe Size	Overall Length
1/2"	1-1/2"
3/4"	1-1/2"
1"	1-7/8"
1-1/4"	2-3/4"
1-1/2"	2-3/4"
2"	3-1/4"

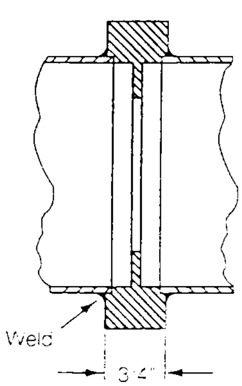


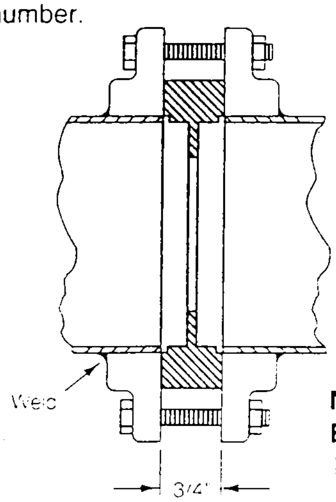
Carbon Steel Orifices (CO)—2-1/2" thru 24"; rated 250 PSI

- Low cost metering device permits accurate setting of burner air & gas flow for optimum efficiency.
- Can be socket-welded to pipes or mounted between flanges (flanges must be ordered separately.)
- ±1% accuracy depending on location, measurement accuracy and proper use of correction factors.
- One piece zinc-plated steel construction.
- Includes brass hex-head screws to plug holes when measurements are not being taken.
- Metal tag chained to valve clearly indicates orifice pipe size and model number.



Socket-Welded

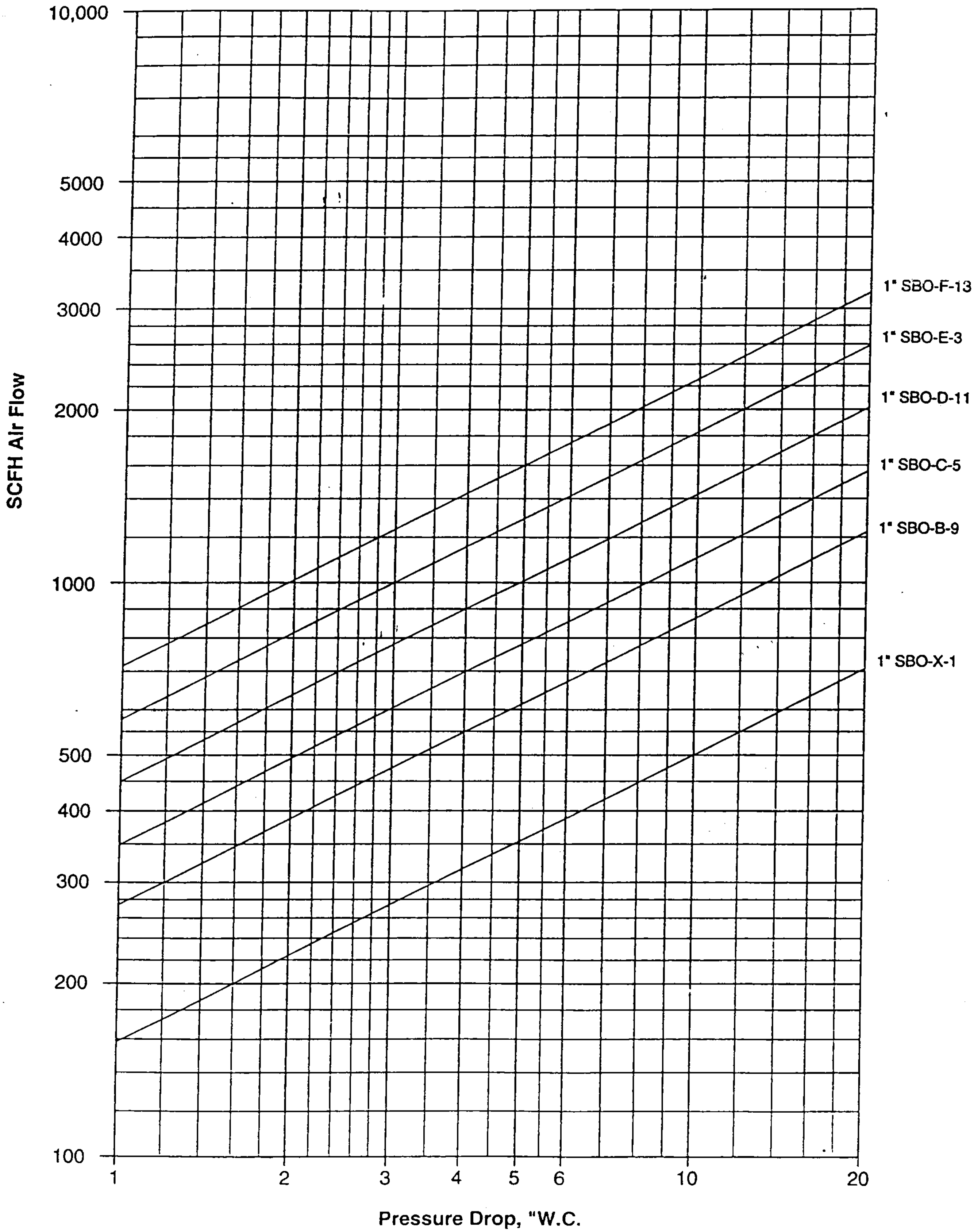




Mounted Between Flanges

Gas Orifice Meters

1" Pipe Size

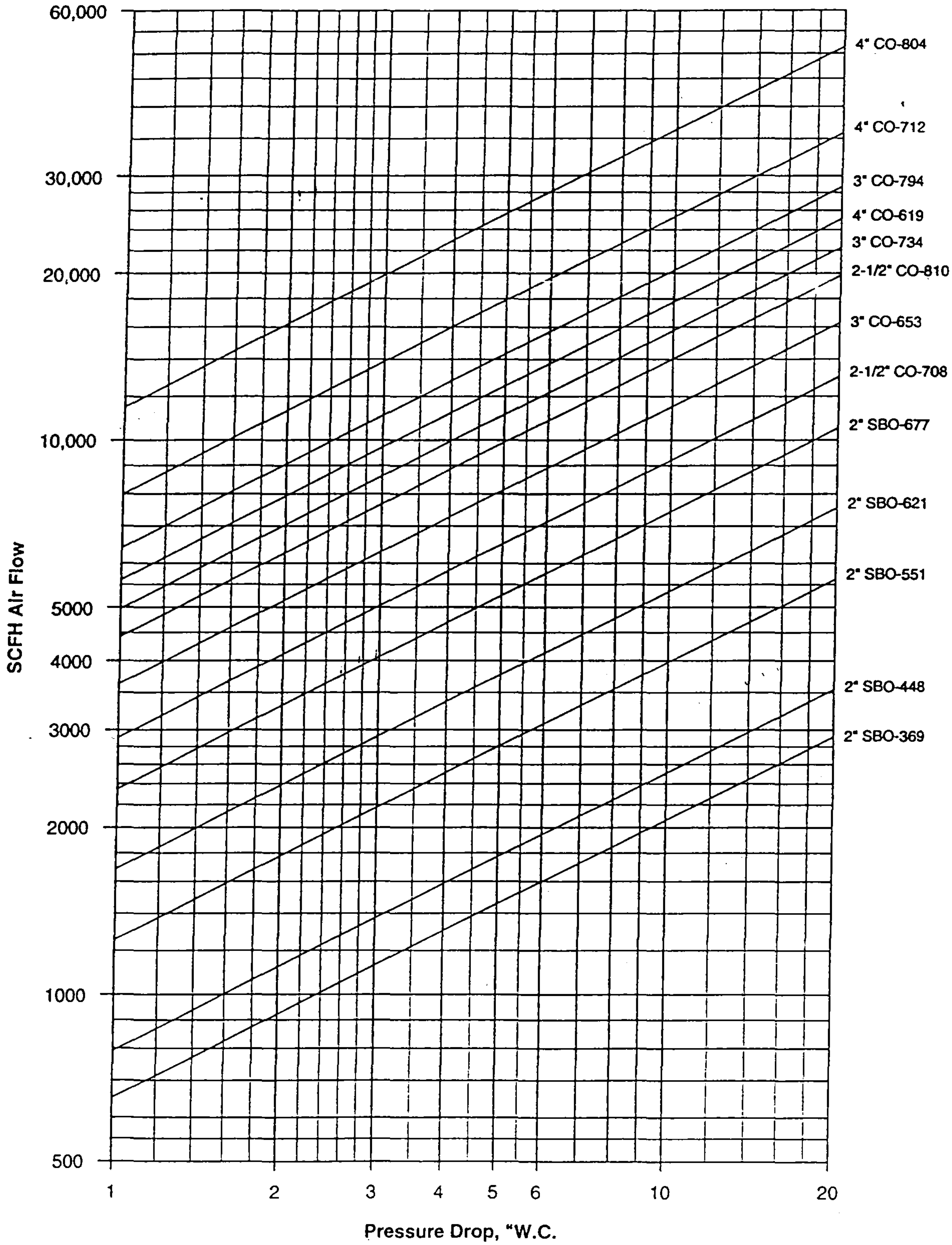


ECLIPSE-DUNGS
CONTROLS INC.

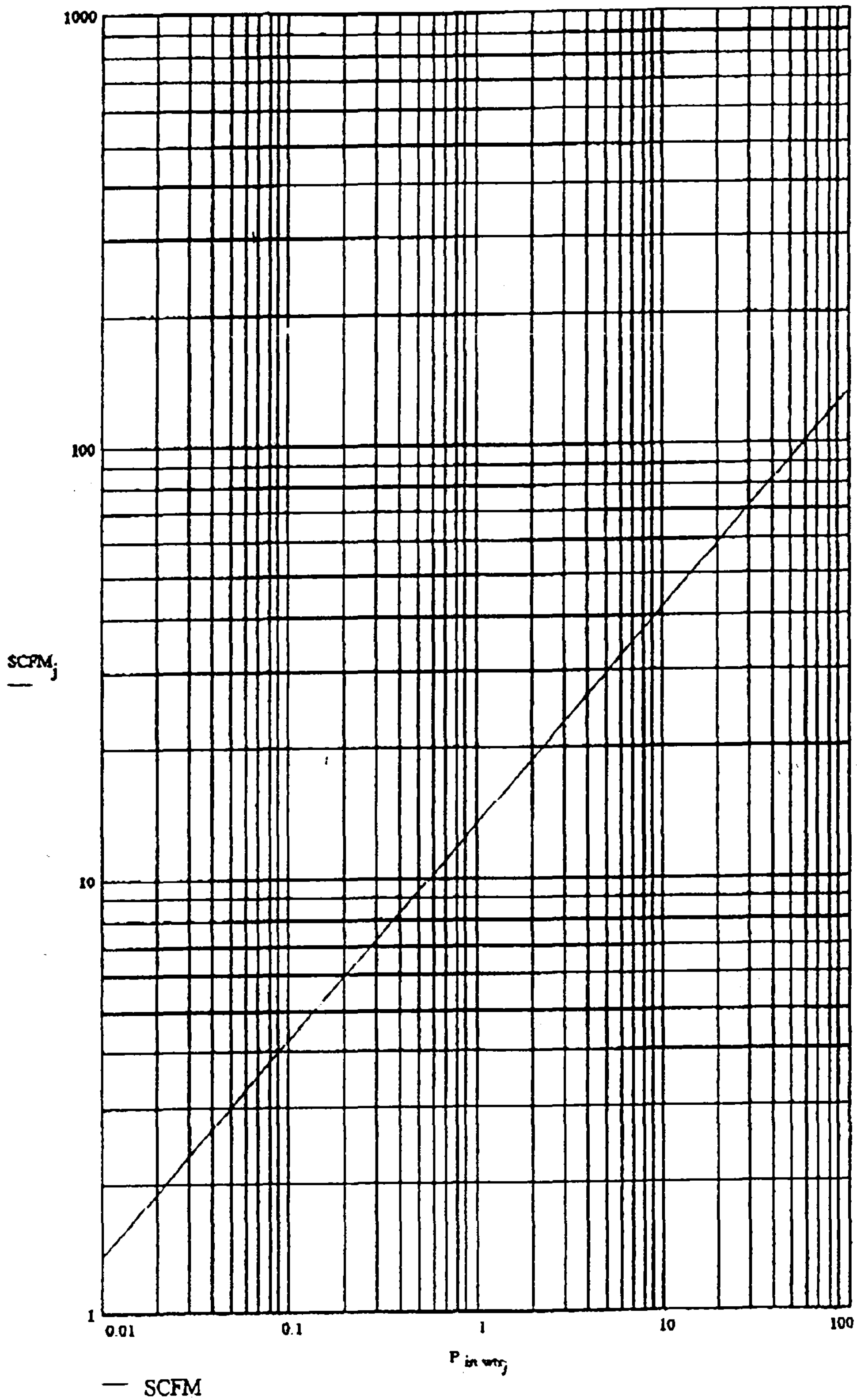
1665 Elmwood Rd. • Rockford, IL • 815-877-3031

Litho in U.S.A.

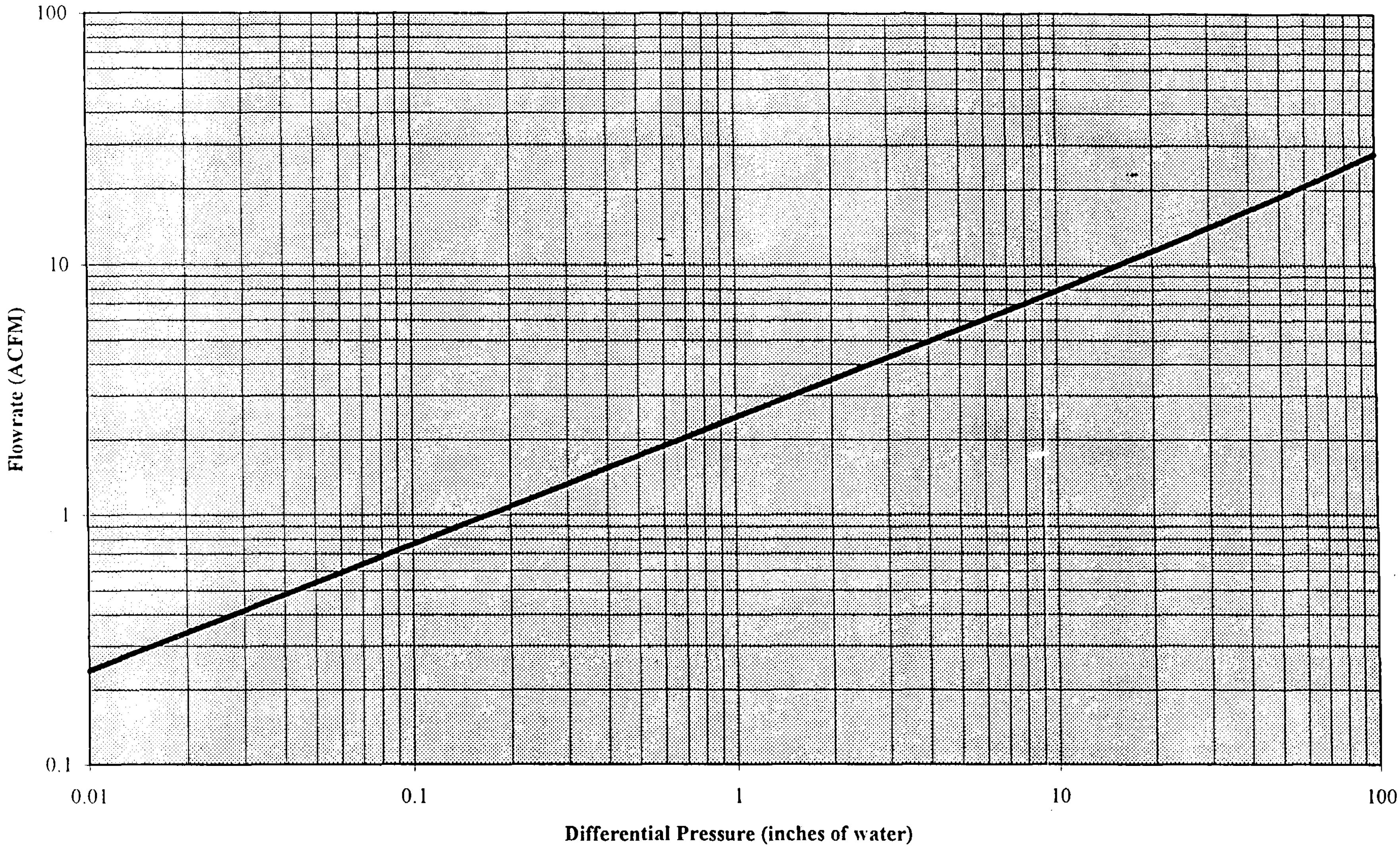
Gas Orifice Meters
2" thru 4" Pipe Sizes



ECLIPSE 2" SBO-448 Conversion Chart



Flowrate versus Differential Pressure



OPERATIONS AND MAINTENANCE MANUAL
MULTIPHASE RECOVERY SYSTEM
FUEL FARM 216
NAS CORPUS CHRISTI, TEXAS

ATTACHMENT 4

STANDARD AIR PERMIT EXEMPTION AND RELATED CORRESPONDENCE

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

STANDARD EXEMPTION LIST

30 TAC §116.211
Control of Air Pollution By Permits For
New Construction or Modification

ADOPTED MAY 15, 1996
EFFECTIVE JUNE 7, 1996

****

68. Equipment used to reclaim or destroy chemicals removed from contaminated ground water, contaminated water condensate in tank and pipeline systems, or contaminated soil, for the purpose of remedial action, provided all the following conditions are satisfied:

(a) Applicability shall pertain to soil and water remediation at the property where the original contamination of the ground water or soil occurred or at a nearby property secondarily affected by the contamination, but not to any soil or water treatment facility where soils or water are brought in from another property. Such facilities are subject to §116.1, relating to Permit Requirements.

(b) For treating groundwater or soil contaminated with petroleum compounds, the total emissions of petroleum hydrocarbons shall not exceed 1.0 pound per hour (lb/hr), except that benzene emissions also must meet the conditions of Standard Exemption 118(c) and (d). For purposes of this exemption, petroleum is considered to include: (1) liquids or gases produced from natural formations of crude oil, tar sands, shale, coal and natural gas, or (2) refinery fuel products to include fuel additives.

(c) For treating groundwater or soil contaminated with chemicals other than petroleum, emissions must meet the requirements of Standard Exemption 118(b), (c), and (d). If the groundwater or soil is contaminated with both petroleum and other chemicals, the petroleum compound emissions must meet condition (b) of this exemption and the other chemical emissions must meet the requirements of Standard Exemption 118(b), (c), and (d). The emission of any chemical not having a Limit (L) Value in Table 118A of Standard Exemption 118 is limited to 1.0 lb/hr.

(d) The handling and processing (screening, crushing, etc.) of contaminated soil and the handling and conditioning (adding moisture) of remediated soil shall be controlled such that there are no visible emissions with the exception of moisture.

(e) If abatement equipment is used to meet conditions (b) and (c), the equipment must satisfy one of the following conditions:

(1) The vapors shall be burned in a direct-flame combustion device (incinerator, furnace, boiler, heater, or other enclosed direct-flame device) operated in compliance with Standard Exemption 88(b) and (c).

(2) The vapors shall be burned in a flare which meets the requirements of Standard Exemption 80 and the requirements of 40 Code of Federal Regulations 60.18 which shall take precedence over Standard Exemption 80 in any conflicting requirements whether or not New Source Performance Standards apply to the flare.

(3) The vapors shall be burned in a catalytic oxidizer which destroys at least 90% of the vapors. An evaluation of oxidizer effectiveness shall be made at least weekly using a portable flame or photoionization detector or equivalent instrument to determine the quantity of carbon compounds in the inlet and outlet of the catalytic oxidizer. Records of oxidizer performance shall be maintained in accordance with condition (g).

(4) The vapors shall be routed through a carbon adsorption system (CAS) consisting of at least two activated carbon canisters that are connected in series. The system shall meet the following additional requirements:

(A) The CAS shall be sampled and recorded weekly to determine breakthrough of volatile organic compounds (VOC). Breakthrough is defined as a measured VOC concentration of 50 parts per million by volume (ppmv) in the outlet of the initial canister. The sampling point shall be at the outlet of the initial canister, but before the inlet to the second or final polishing canister. Sampling shall be performed while venting maximum emissions to the CAS. (Example: during loading of tank trucks, during tank filling, during process venting.)

(B) A flame ionization detector (FID) shall be used for VOC sampling. The FID shall be calibrated prior to sampling with certified gas mixtures (propane in air) of 10 ppmv $\pm$ 2.0% and of 100 ppmv $\pm$ 2.0%.

(C) When the VOC breakthrough is measured, the waste gas flow shall be switched to the second canister immediately. Within four hours of detection of breakthrough, a fresh canister shall be placed as the new final polishing canister. Sufficient fresh activated carbon canisters shall be maintained at the site to ensure fresh polishing canisters are installed within four hours of detection of breakthrough.

(D) Records of the CAS monitoring maintained at the plant site shall include, but are not limited to, the following:

1. sample time and date,

2. monitoring results (ppmv),

3. corrective action taken, including the time and date of the action, and

4. process operations occurring at the time of sampling.

(E) The registration shall include a demonstration that activated carbon is an appropriate choice for control of the organic compounds to be stripped.

(f) Before construction of the facility begins, the facility shall be registered with the Texas Natural Resource Conservation Commission (TNRCC) Office of Air Quality in Austin using Form PI-7. The registration shall contain specific information concerning the basis (measured or calculated) for the expected emissions from the facility. The registration shall also explain details as to why the emission control system can be expected to perform as represented.

(g) Records required by applicable paragraphs of this exemption shall be maintained at the site and made available to personnel from the TNRCC or any local agency having jurisdiction. These records shall be made available to representatives of the TNRCC and local programs upon request and shall be retained for at least two years following the date that the data is obtained.

(d) The oven, furnace, and/or incinerator shall be equipped with an afterburner automatically controlled to operate with a minimum temperature of 1,400°F and a gas retention time of 0.5 second or greater.

(e) Opacity of emissions from the oven, furnace, and/or incinerator shall not exceed 5% averaged over a 5-minute period.

(f) Manufacturer's recommended operating instructions shall be posted at each oven, furnace, and/or incinerator; and each unit shall be operated in accordance with these instructions.

(g) Heat shall be provided by the combustion of sweet natural gas, liquid petroleum gas, or No. 2 fuel oil with no more than 0.5% sulfur by weight; or by electric power.

(h) The emission of any air contaminant shall not exceed 0.5 lb/hr and 2.0 tpy.

88. Direct flame incinerators installed for the purpose of reducing or eliminating non-halogenated VOC vapors and/or aerosols (but not liquids or solids), provided the following conditions are satisfied:

(a) Before construction beings, the facility shall be registered with the appropriate regional office using Form PI-7.

(b) Each direct flame incinerator shall be automatically controlled to maintain a minimum temperature of 1,400°F in the combustion chamber (secondary chamber if dual chambered) and a gas retention time of 0.5 second or greater.

(c) Continuous temperature monitors to record the temperature of the combustion chamber (secondary chamber if dual chambered) shall be installed and maintained. Temperature data shall be maintained on a rolling 2-year retention basis and shall be made available at the request of personnel from the TACB or any local air pollution control program having jurisdiction.

(d) Manufacturer's recommended operating instructions shall be posted at each incinerator and each unit shall be operated in accordance with these instructions.

(e) Opacity of emissions from the incinerator shall not exceed 5% averaged over a 5-minute period.

(f) There shall be no obstructions to stack flow, such as by rain caps, unless such devices are designed to automatically open when the incinerator is in operation. Properly installed and maintained spark arrestors are not considered obstructions.

(g) Heat for the incinerator shall be provided by the combustion of sweet natural gas, liquid petroleum gas, or No. 2 fuel oil with no more than 0.5% sulfur by weight or by electric power.

(h) The gases being incinerated shall contain no halogenated organic compounds.

(i) This standard exemption shall not apply to catalytic incinerators, or direct flame incinerators installed to control emissions from new or modified facilities subject to the requirements of 31 TAC Chapter 116.

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

STANDARD EXEMPTION LIST

30 TAC §116.211
Control of Air Pollution By Permits For New Construction or Modification

ADOPTED MAY 15, 1996
EFFECTIVE JUNE 7, 1996

****

118. Facilities, or physical or operational changes to a facility, provided that all of the following conditions are satisfied:

(a) This exemption shall not be used to authorize construction or any change to a facility specifically authorized in another standard exemption, but not meeting the requirements of that exemption. However, once the requirements of a specific exemption are met, Exemption 118(c) and (d) may be used to qualify the use of other chemicals at the facility.

(b) Emission points associated with the facilities or changes shall be located at least 100 feet from any off-plant receptor*.

(c) New or increased emissions, including fugitives, of chemicals shall not be emitted in a quantity greater than five tons per year nor in a quantity greater than E as determined using the equation E = L/K and the following table.

D, Feet	K
100	326
200	200
300	139
400	104
500	81
600	65
700	54
800	46
900	39
1,000	34
2,000	14
3,000 or more	8

E = maximum allowable hourly emission, and never to exceed 6 pounds per hour.

L = value as listed or referenced in Table 118A.

K = value from the table on this page. (interpolate intermediate values)

D = distance to the nearest off-plant receptor.

(d) Notification must be provided using Form PI-7 within 10 days following the installation or modification of the facilities. The notification shall include a description of the project, calculations, and data identifying specific chemical names, L values, D values, and a description of pollution control equipment, if any.

TABLE 118A
LIMIT VALUES (L) FOR USE WITH STANDARD EXEMPTION 118

Values included in this table represent screening levels for determining the applicability of Standard Exemption 118 and other standard exemptions using the Exemption 118 equation. The values are not to be interpreted as acceptable health effects values relative to the issuance of construction permits, special permits, or operating permits under 30 TAC Chapter 116.

Compound	Limit (L) Milligrams Per Cubic Meter
Acetone	590
Acetaldehyde	9
Acetone Cyanohydrin	4
Acetonitrile	34
Acetylene	2662
Adiponitrile	18
Aldrin	0.15
Sec-Amyl Acetate	1.1
Arsenic	0.01
Benzene	3
Beryllium and Compounds	0.0005
Butyl Acrylate	19
Butyl Glycidyl Ether	30
Butyl Mercaptan	0.3
Butyraldehyde	1.4
Butyric Acid	7.3
Butyronitrile	22
Carbon Tetrachloride	12
Chloroform	10
Chlorophenol	0.2
Chloroprene	3.6
Chromic Acid	0.05
Chromium and Compounds	0.025
Coal Tar Pitch Volatiles	0.1
Creosote	0.1
Cresol	0.12
Cumene	43
o-Dichlorobenzene	180
p-Dichlorobenzene	108
1,2-dichloroethylene	79
Dicyclopentadiene	3.1
Diethylaminoethanol	5.5

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

STANDARD EXEMPTION LIST

30 TAC §116.211
Control of Air Pollution By Permits For New Construction or Modification

ADOPTED MAY 15, 1996
EFFECTIVE JUNE 7, 1996

****

TABLE 118A Cont'd.

Compound	Limit (L) Milligrams Per Cubic Meter
Dicyclopentadiene	3.1
Diethylaminoethanol	5.5
Diisobutyl Ketone	140
Dimethyl Aniline	6.4
Dimethylhydrazine	0.15
Dioxane	3.6
Dipropylamine	8.4
Ethyl Acrylate	0.5
Ethylene Dibromide	1
Ethylene Glycol Dinitrate	0.1
Ethylene Oxide	0.18
Ethyl Mercaptan	0.15
Ethyl Sulfide	1.6
Fibrous Glass Dust	5
Gylcolonitrile	5
Heptane	350
Hydrazine	0.04
Hydrogen Chloride	1
Hydrogen Sulfide	1.1
Isoamyl Acetate	13
Isoamyl Alcohol	15
Isobutyronitrile	22
Isophorone Diisocyanate	0.045
Kepone	0.001
Kerosene	100
Malononitrile	8
Mercury, Inorganic	0.05
Mesityl Oxide	40
Methyl Acrylate	1.7
Methyl Amyl Ketone	5.8
Methyl Butyl Ketone	4
Methyl Disulfide	2.2
Methylenebis (Chloroaniline) MOCA	0.003
Methylenebis (Phenyl isocyanate)	0.05
Methylene Chloride	26

****

TABLE 118A Cont'd.

Compound	Limit (L) Milligrams Per Cubic Meter
Methyl Mercaptan	0.3
Methyl Methacrylate	34
Methyl Propyl Ketone	530
Methyl Sulfide	0.5
Mineral Spirits	350
Naphtha	350
Nickel, Inorganic Compounds	0.015
Nitroglycerine	0.1
Nitropropane	36
Octane	350
Parathion	0.05
Pentane	350
Perchloroethylene	33.5
Petroleum Ether	350
Phenyl Glycidyl Ether	5
Phenylhydrazine	0.6
Phenyl Mercaptan	0.4
Propionitrile	14
Propyl Acetate	281
Propylene Oxide	5
Propyl Mercaptan	0.08
Stoddard Solvent	350
Styrene	21
Succinonitrile	20
Tolidine	0.02
Trichloroethylene	135
Trimethylamine	0.1
Valeric Acid	0.34
Vinyl Acetate	15
Vinyl Chloride	2

Barry R. McBee, *Chairman*
R. B. "Ralph" Marquez, *Commissioner*
John M. Baker, *Commissioner*
Dan Pearson, *Executive Director*

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

January 22, 1997

Mr. John Young
Engineering Technician
C/O Commanding Officer
Code 189
Naval Air Station Corpus Christi
1101 D Street
Suite 143
Corpus Christi, Texas 78419-5021

Re: Standard Exemption
Registration No. 33805
Fuel Farm 216
Corpus Christi, Nueces County
Account ID No. 93-3805-S

Dear Mr. Young:

This is in response to your request to register the operation of another soil and groundwater remediation pilot test under Standard Exemption 68 at Fuel Farm 216 at Naval Air Station, Corpus Christi, Nueces County. We understand that you will use a carbon adsorption system to abate air emissions during the pilot test. You have indicated that abated emissions of total petroleum hydrccarbons and benzene will not exceed 1.0 and 0.029 pounds per hour, respectively. We further understand that you will locate the emissions point at least 400 feet away from any off-site receptors.

Accordingly, and after evaluating the entirety of your submittal, we have determined that your operation conforms to the criteria of Standard Exemptions 68 and 118, if constructed and operated as described in your application. The Executive Director of the Texas Natural Resource Conservation Commission (TNRCC) authorized these standard exemptions pursuant to 30 TAC Section 116.211 of Regulation VI. We have enclosed copies of the exemptions in effect at the time of this registration. You must operate in accordance with all requirements of those standard exemptions.

Re: Standard Exemption
Registration No. 33805

We remind you that regardless of whether a permit is required, you must maintain these facilities in compliance with all air quality rules and regulations of the TNRCC and of the U.S. Environmental Protection Agency at all times.

We appreciate your cooperation in this matter. If you have any questions concerning this exemption, please contact Mr. Terry Murphy of our Office of Air Quality, New Source Review Permits Division at (512) 239-1587.

Sincerely,

Tammy Villarreal
Manager, Chemical Section
New Source Review Permits Division
Texas Natural Resource Conservation Commission

TV/TM/ms

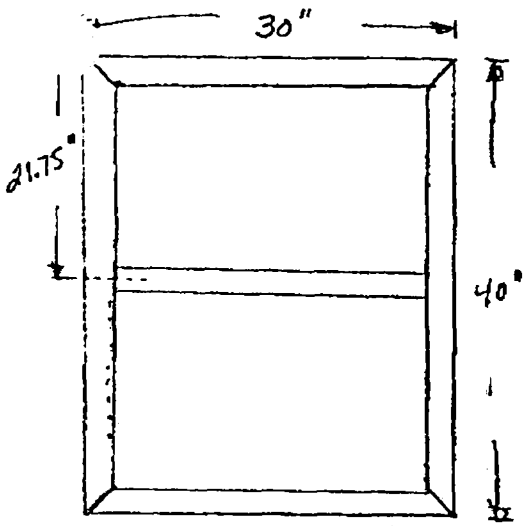
Enclosures

cc: Mr. Charlie Spiekerman, Air Program Manager, Corpus Christi

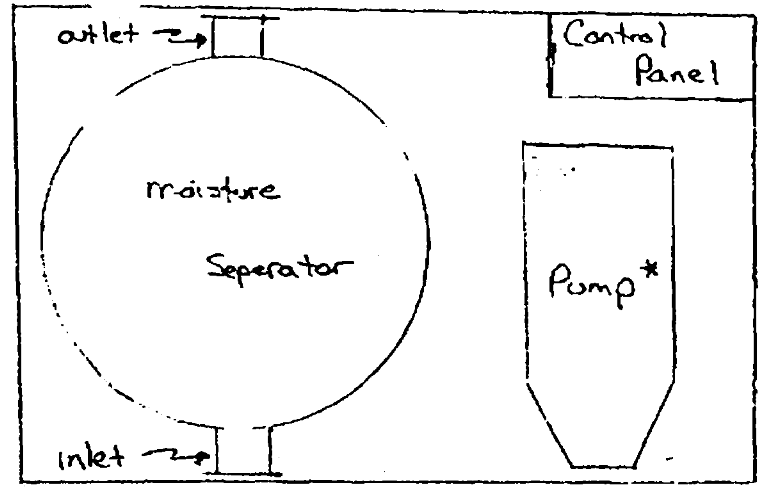
Record No. 48193

ATTACHMENT 5

CONDENSATE COLLECTOR (T-7) AND CONDENSATE TRANSFER PUMP (P-3)



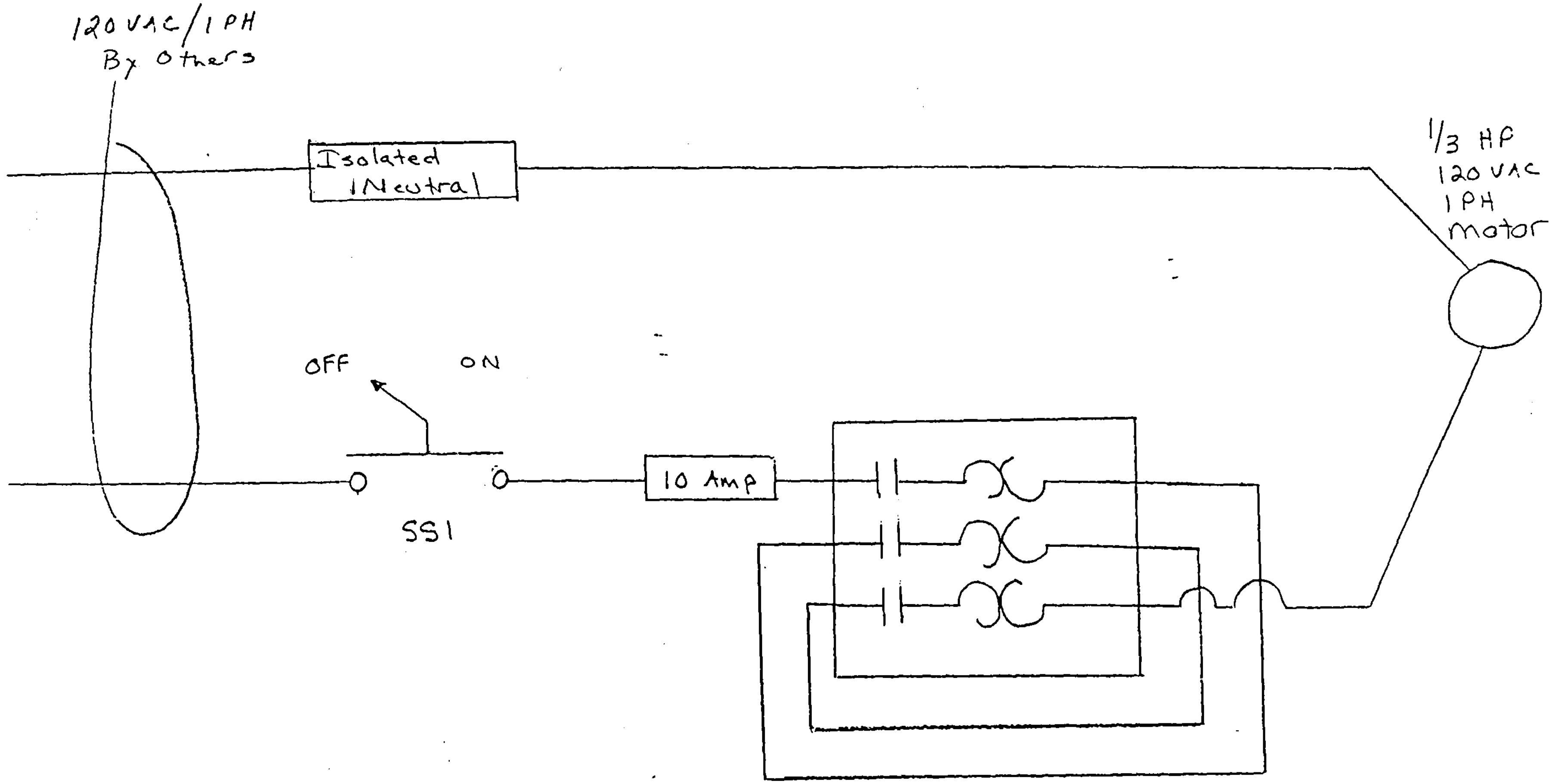
Footprint



General Arraingment

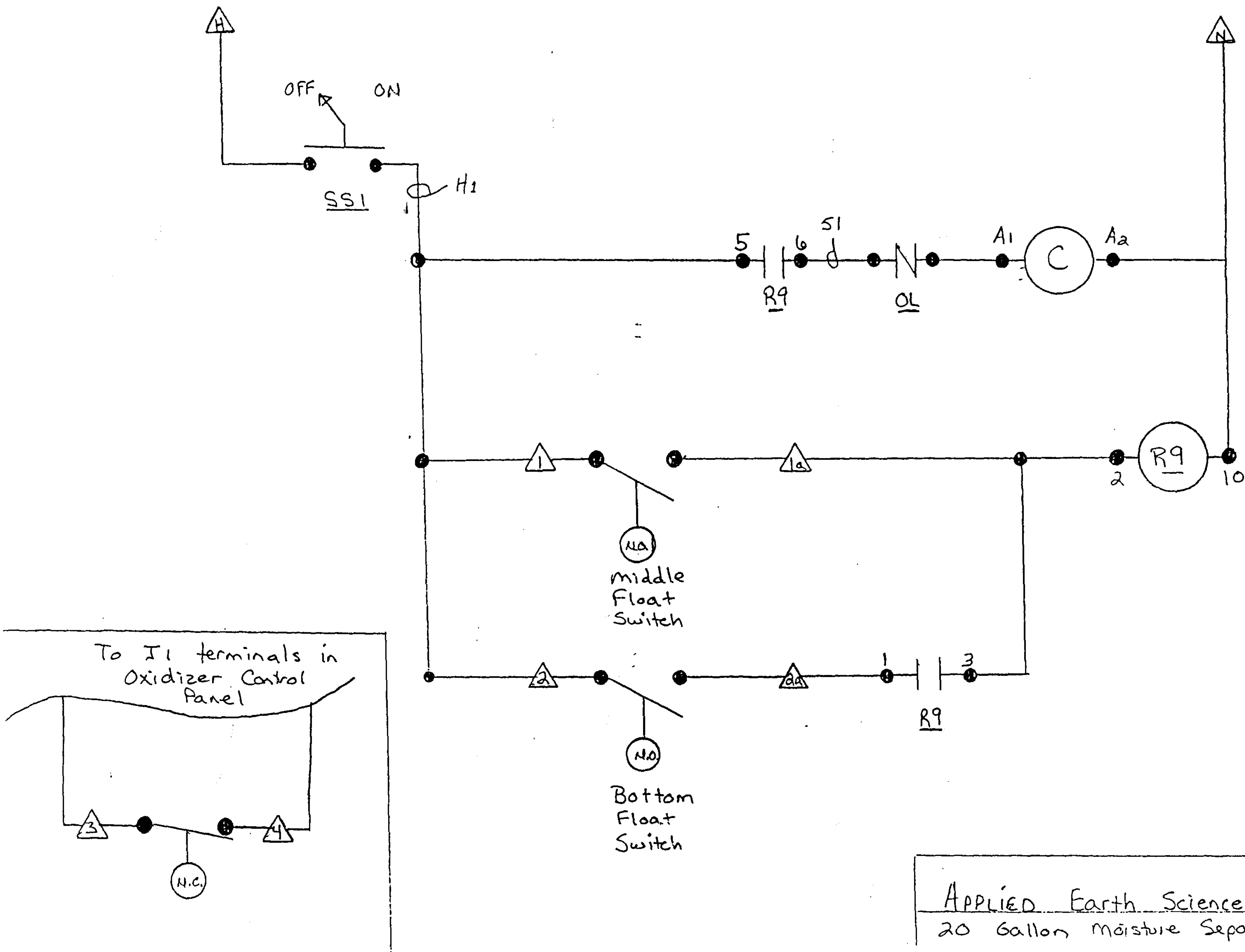
* Position dependant upon rotation of pump

Applied Earth Science #969



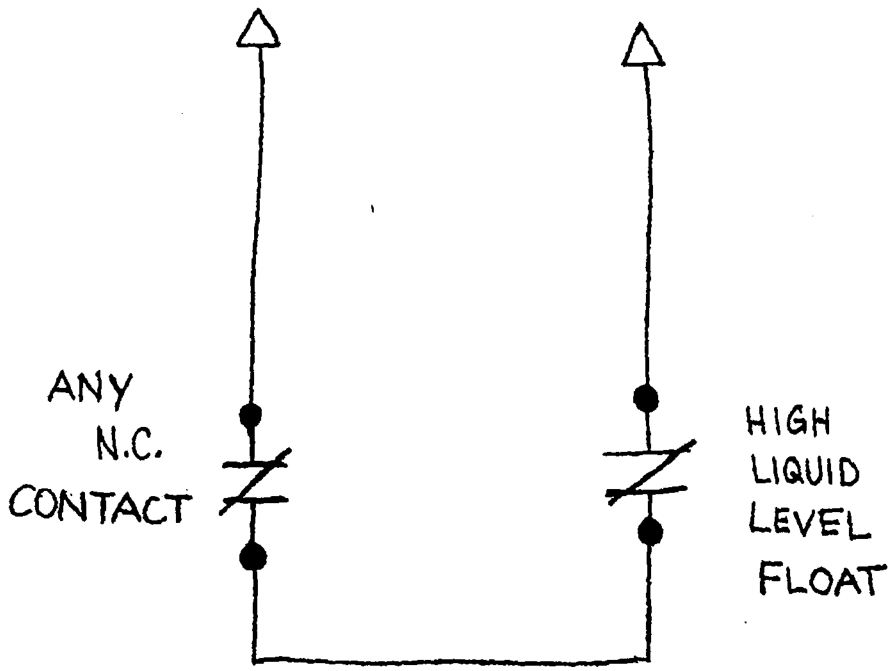
Applied Earth Science #969

20 gallon Moisture Separator
One-line diagram



Applied Earth Sciences #909
20 Gallon Moisture Separator

WIRE J-1 IN SERIES



Fisher Controls

Instruction Manual

289 Series Relief Valves

FISHER®

August 1990 *Form 1724*

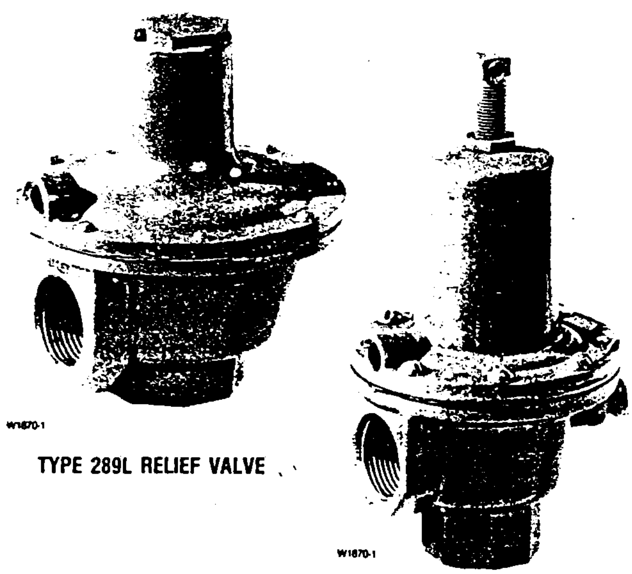
Introduction

Scope of Manual

This instruction manual provides installation, maintenance, and parts ordering information for the 289 Series relief valves. Instructions for other equipment used with these relief valves can be found in separate instruction manuals.

Description

The 289 Series pressure relief valves (see figure 1) are throttling relief valves used downstream of pressure regulators to protect the downstream system from overpressure. These relief valves can be used for natural gas, air, propane, or other noncorrosive, gas-flow service.



TYPE 289L RELIEF VALVE

TYPE 289H RELIEF VALVE

Figure 1. Typical 289 Series Relief Valves

Specifications

Specifications for the 289 Series relief valves are given in table 1.

Installation

WARNING

Installing a 289 Series relief valve where its capabilities can be exceeded or where proper operation might be impaired may cause personal injury, property damage, or leakage due to bursting of pressure-containing parts or explosion of accumulated gas. To avoid such conditions, install a 289 Series relief valve where:

- **Service conditions are within the unit capabilities specified in tables 1 and 2, and**
- **The relief valve is protected from exposure to physical damage and/or corrosive substances.**

1. When installing a 289 Series relief valve, make sure that the installation of the system complies with applicable local, state, or federal codes or regulations.

2. Use qualified personnel when installing, operating, and maintaining a 289 Series relief valve. Before installation, make sure there is no damage to or foreign material in the relief valve and that all piping is clean and unobstructed.

3. For installation of Type 289H, 289HH, and 289L relief valves, the vent in the spring case must remain plugged or undrilled in order for the pitot tube to function properly.

Table 1. Specifications

Available Configurations See table 2 **Body Sizes and End Connection Styles** **Type 289L:** ■ 3/4 or ■ 1 in. NPT screwed **Types 289A and 289U:** 1/4 in. NPT screwed **Type 289H:** ■ 1 or ■ 2 in. NPT screwed **Type 289HH:** 1 in. NPT screwed **Maximum Allowable Relief (Inlet) Pressure and Relief Pressure Set Ranges** See table 2 **Material Temperature Capabilities** **With Nitrile and Neoprene Elastomers:** −20 to 150°F (−29 to 66°C) **With Fluoroelastomer[1]:** 20 to 300°F (−7 to 149°C); available with Types 289H and 289HH only	**Pressure Setting Adjustment** Adjusting screw **Pressure Registration** Internal **Approximate Weight, LB (kg)** **Types 289A and 289U:** 0.75 (0.3) **Type 289H:** *1 In. Size:* 4 (1.8) *2 IN. Size:* 1.5 (0.7) **Type 289HH:** 4 (1.8) **Type 289L:** 1.5 (0.7) **Additional Specifications** For construction materials, see parts list

1. Bubble-tight shutoff can not be attained at settings below 5 psig (.34 bar) with fluoroelastomer O-ring seat.

4. The 289 Series relief valves may be installed in any orientation. However, if installing the relief valve at an outside location, adequate protection, such as raincaps or elbow piping (see figure 2), must be attached to the outlet to keep the relief valve from getting plugged or from collecting moisture, corrosive chemicals, or other foreign materials. If piping is to be attached to the valve outlet, the following parts (if they are connected to the valve outlet as shown in figures 4 through 8) must first be removed: the screen (key 9), the snap ring (key 13), and the gasket (key 15). A typical installation of a 289 Series relief valve is shown in figure 2.

WARNING

If using a 289 Series relief valve on hazardous or flammable gas service, personal injury and property damage could occur due to fire or explosion of vented gas that may have acumulated. To prevent such injury or damage, provide piping or tubing to vent the gas to a safe, well-ventilated area. Also, when venting a hazardous gas, the piping or tubing should be located far enough away from any buildings or windows so to not create a further hazard, and the vent opening should be protected against anything that could clog it.

5. Apply pipe compound to the male pipeline threads only; do not apply pipe compound to the internal body threads. Then install the relief valve so that the flow through it will match the direction arrow or marking cast on the valve body.

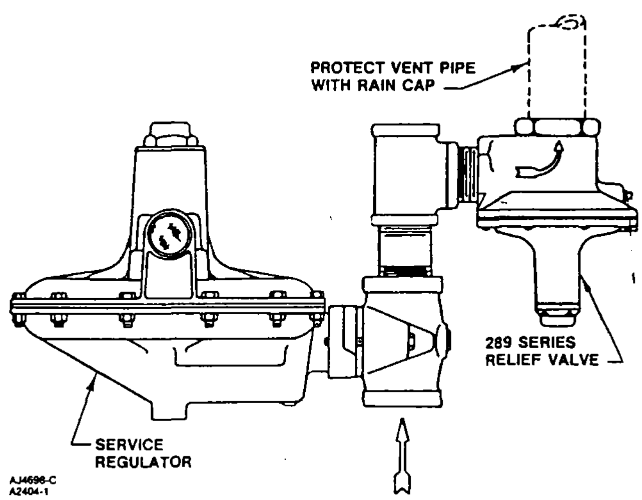


Figure 2. Typical Installation

Startup

Key numbers are shown in figures 4 through 8.

With proper installation completed and system equipment properly adjusted, close any vent valves, and slowly open the upstream shutoff valve while using pressure gauges to monitor pressure.

Note

To ensure proper operation of the pitot tube, if present, the spring case (key 2) must be tightly sealed. It is recommended that the gasket (key 15) be replaced whenever the closing cap (key 14) is removed.

Errata Sheet
for

289 Series Relief Valves
Form 1724, August 1990

When installing the molded diaphragm in the 289 Series Relief Valves, make sure the diaphragm convolution is installed in the down position as shown in figure1.

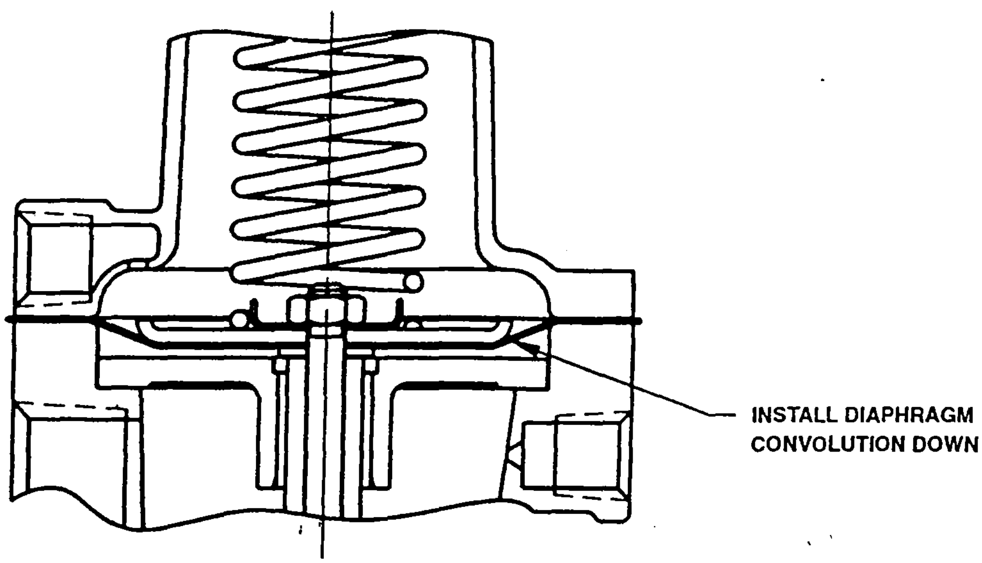


Figure 1. Installation of Diaphragm

Table 2. Maximum Allowable Relief (Inlet) Pressure

AVAILABLE CONFIGURATION	BODY SIZE, INCH	SPRING PART NUMBER	COLOR CODE	SPRING RANGE (RELIEF PRESSURE SETTINGS)		MAXIMUM ALLOWABLE RELIEF (INLET) PRESSURE(1)	
						Psig	Bar
289A	1/4	0Z0563 27022 1B2682 27022	Silver	3 to 13 psig 11 to 22 psig	0.2 to 0.9 bar 0.8 to 1.5 bar	45	3.1
289H	1	1F8269 27052 1D8923 27022 1D7515 27022 1D7455 27142	Pink Red Silver Green	1 to 4.5 psig 4 to 15 psig 10 to 20 psig 15 to 50 psig	69 to 310 mbar 0.3 to 1.0 bar 0.7 to 1.4 bar 1.0 to 3.4 bar	100	6.9
	2	1B5365 27052 1B5366 27052 1B5368 27052 1B5369 27052	Dark blue Gray Dark green Red stripe	7 to 18 inch wc 0.5 to 2.25 psig 1.75 to 7 psig 4 to 10 psig	17 to 45 mbar 35 to 155 mbar 121 to 483 mbar 0.3 to 0.7 bar	25	1.7
289HH	1	1D7455 27142	Green	45 to 75 psig	3.1 to 5.2 bar	100	6.9
289L	3/4 or 1	1B4135 27222 1N3112 X0012 13A7917 X012 13A7916 X012	Silver Stainless steel Silver Silver	3 to 8 inch wc 5 to 18 inch wc 10 to 18 inch wc 12 to 40 inch wc	7 to 20 mbar 12 to 45 mbar 25 to 45 mbar 30 to 100 mbar	7	0.5
289U	1/4	0V0602 27022 0F0582 27022	Silver Silver	5 to 25 inch wc 20 inch wc to 3 psig	12 to 62 mbar 50 to 206 mbar	10	0.7

1. This value indicates the relief pressure setting plus pressure buildup.

Antiseizing sealant should be applied to the adjusting screw (key 6) threads on valves without closing caps.

If set pressure adjustment is necessary, monitor the inlet pressure with a gauge during the adjustment procedure. Remove the closing cap (key 14), or loosen the hex nut (key 11), and turn the adjusting screw (key 6) clockwise to increase or counterclockwise to decrease the relief pressure setting.

For 2-inch Type 289H relief valves, when changing from one spring range to another, it is recommended that a new spring case be used so that the travel stop drive screw will be positioned correctly for the corresponding spring range. Each spring range requires that the travel stop drive screw be positioned appropriately in the spring case to prevent setting the relief valve pressure too high. The location of the travel stop drive screw for each spring and spring range is shown in figure 3.

SPRING PART NUMBER	SPRING RANGE (RELIEF PRESSURE SETTING)		DIMENSION A	
			Inch	mm
1B5365 27052	7 to 18 inch wc	17 to 45 mbar	Drive screw not required	
1B5366 27052	0.5 to 2.25 psig	35 to 155 mbar	1-17/32	39
1B5368 27052	1.75 to 7 psig	121 to 483 mbar	2-5/32	55
1B5369 27052	4 to 10 psig	0.3 to 0.7 bar	2-5/16	59

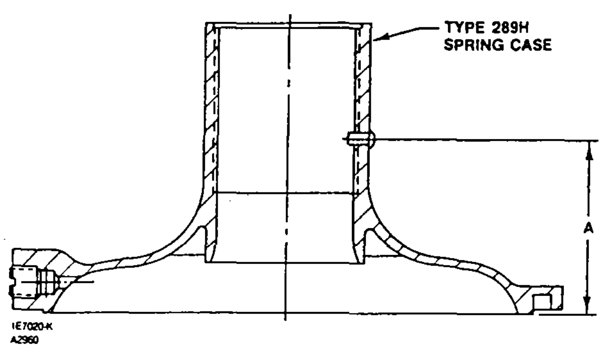


Figure 3. Location of Travel Stop Drive Screw for 2-Inch, Type 289H Relief Valve

Shutdown

Close the upstream shutoff valve, and release all pressure from the relief valve.

Maintenance

Relief valve parts are subject to normal wear and should be inspected periodically for maintenance. The frequency of inspection and replacement of parts depends upon the severity of service conditions.

This section contains information for inspection and maintenance of 289 Series relief valves. Maintenance procedures are presented for relief valve configurations of similar construction. Refer to the appropriate procedure and figure for the particular relief valve configuration when changing the control spring to one of a different range or when inspecting, cleaning, or replacing any other relief valve parts. The screen (key 9, figures 4 through 7) and vent piping, if present, should be free of foreign material that might impair relief flow.

Note

The relief valve body (key 1, figures 4 through 8) may remain in the pipeline during maintenance unless replacement of the valve body is necessary.

WARNING

Avoid personal injury or property damage from sudden release of pressure or explosion of accumulated gas. Before starting disassembly:

- **Isolate the relief valve from line pressure, and**
- **Release trapped pressure from the valve body and pressure line.**

Type 289A Relief Valves

All key numbers are shown in figure 4.

1. Loosen the hex nut (key 11), and unscrew the adjusting screw (key 6) to relieve spring compression.

2. Unscrew the machine screws (key 8), and remove the spring case (key 2), the spring seat (key 4), the spring (key 7), the diaphragm head (key 3) and the diaphragm (key 5).

3. Inspect the diaphragm and seating surfaces for damage or wear, and replace parts as necessary. To remove the orifice (key 10) unscrew it from the body.

4. Reinstall the orifice, the diaphragm, the diaphragm head, the spring, and the spring seat.

5. Reattach the spring case using the machine screws.

6. If a new spring with a different range is installed, stamp the spring case with the new spring range.

7. Adjust the spring compression according to the procedures outlined in the Startup section.

Type 289U Relief Valves

All key numbers are shown in figure 5.

1. Loosen the hex nut (key 11), and unscrew the adjusting screw (key 6) to relieve spring compression.

2. Unscrew the machine screws (key 8), and remove the spring case (key 2), the spring seat (key 4), the spring (key 7), and the diaphragm assembly (key 5).

3. Inspect the diaphragm assembly and seating surfaces for damage or wear, and replace parts as necessary.

4. Reinstall the diaphragm assembly, the spring, and the spring seat.

5. Reattach the spring case using the machine screws.

6. If a new spring with a different range is installed, stamp the spring case with the new spring range.

7. Adjust the spring compression according to the procedures outlined in the Startup section.

Type 289L Relief Valves

All key numbers are shown in figure 6.

1. Remove the closing cap (key 14) and the gasket (key 15), and then unscrew the adjusting screw (key 6) to relieve spring compression.

2. Unscrew the machine screws (key 8), and then remove the spring case (key 2), the spring (key 7), and the diaphragm assembly (key 5).

3. Inspect the diaphragm and seating surfaces for damage or wear, and replace parts as necessary. To remove the orifice (key 10), unscrew it from the body. Check the pitot tube in the diaphragm assembly for blockage, and remove any foreign material that might impair proper operation of the relief valve.

4. Reinstall the orifice, the diaphragm assembly, and the spring.

5. Reattach the spring case using the machine screws.

6. If a new spring with a different range is installed, stamp the closing cap with the new spring range.

7. Adjust the spring compression according to the procedures outlined in the Startup section, and then reinstall the closing cap and gasket.

Type 289HH and 1-Inch Type 289H Relief Valves

All key numbers are shown in figure 7.

1. Loosen the hex nut (key 11), and then unscrew the adjusting screw (key 6) to relieve spring compression.

2. Unscrew the machine screws (key 8), and remove the spring case (key 2), the spring seat (key 4), and the spring (key 7).

3. Unscrew the hex nut (key 24), and remove the lower spring seat (key 17), the diaphragm head (key 3), and the diaphragm (key 5).

4. Unscrew the machine screws (key 29), and then remove the stem guide assembly (key 31) and attached parts from the valve body (key 1).

5. Slide the spacer (key 23) and the pitot tube (key 18) and attached parts from the valve body.

6. Remove the washer (key 27), the gasket (key 19), the spacer, the O-rings (key 30), the O-ring holder (key 21), the O-ring (key 20), and the O-ring washer (key 22) from the pitot tube.

7. Inspect the O-rings, the gaskets, the spacer, the orifice, and the seating surfaces for damage or wear, and replace parts as necessary.

8. Apply antiseizing sealant to the adjusting screw threads, and to the end of the adjusting screw that contacts the spring seat.

9. Slide the O-ring washer, the O-rings (keys 30 and 20), the O-ring holder, the O-ring (key 30), the spacer, the stem guide assembly, the gasket, and the washer (key 27) onto the pitot tube.

10. Reinstall the stem guide assembly with attached parts into the valve body, and then attach this assembly with the machine screws (key 29).

11. Replace the diaphragm, the diaphragm head, and the lower spring seat, and then secure these parts with the hex nut (key 24).

12. Reinstall the spring and the spring seat, and then attach the spring case to the valve body using the machine screws (key 8).

13. If a new spring with a different range is installed, stamp the spring case with the new spring range.

14. Adjust the spring compression according to the procedures outlined in the Startup section.

2-Inch Type 289H Relief Valves

All key numbers are shown in figure 8.

1. Remove the closing cap and the gasket (keys 14 and 15), and then unscrew the adjusting screw (key 6) to relieve spring compression.

2. Unscrew the machine screw (key 8), and remove the spring case (key 2), the washer (key 27), and the spring (key 7).

3. Unscrew the hex nut (key 24), unscrew the lifting stem (key 25), and then unscrew the hex nut (key 11).

4. Remove the lower spring seat (key 17), the diaphragm head (key 3), the diaphragm (key 5), the lower diaphragm head (key 26), and the gasket (key 19).

5. Unscrew the machine screws (key 29), and then remove the stem guide assembly (key 31) and attached parts.

6. Slide the spacer (key 23) and the pitot tube (key 18) and attached parts out of the stem guide assembly.

7. Remove the gaskets (key 19), the spacer (key 23), and the O-ring washer (key 22) from the pitot tube. Then remove the O-ring washer (key 20) and the orifice (key 10) from the valve body (key 1).

8. Inspect the O-rings, the gaskets, the spacer, the orifice, and the seating surfaces for damage or wear, and replace parts as necessary.

9. Apply antiseizing sealant to the orifice threads, and then to the adjusting screw threads.

10. Reinstall the orifice and the O-ring (key 20) into the valve body.

11. Slide the gasket, the O-ring washer, the gasket, the spacer, the stem guide assembly, and the gasket onto the pitot tube.

12. Reinstall the stem guide assembly with attached parts into the valve body, and attach it with the machine screws (key 29).

13. Replace the lower diaphragm head, the diaphragm, the diaphrahm head, and the lower spring seat; then secure these parts with the hex nut (key 11). Screw in the lifting stem, and lock it in place with the hex nut (key 24).

14. Reinstall the spring and the washer.

Note

For 2-inch Type 289H relief valves, when changing from one spring range to another, use a new spring case to position the travel stop drive screw correctly for the corresponding spring range. Each spring range requires that the travel stop drive screw be positioned appropriately in the spring case to prevent setting the relief valve pressure too high. The location of the travel stop drive screw for each spring and spring range is shown in figure 3.

5. Attach the spring case to the valve body using the ır ·e screws (key 8).

6. If a new spring with a different range is installed, tamp the spring case with the new spring range.

7. Adjust the spring compression according to the rocedures outlined in the Startup section. Then install ıe gasket and the closing cap.

'arts Ordering

Vhen corresponding with your Fisher sales office or ales representative about this equipment, always reference the equipment serial number stamped on the pring case (key 2) or the closing cap (key 14). When rdering replacement parts, specify the complete 11-ıaracter part number of each required part as found in ıe following parts list.

'arts List

ey	Description	Part Number
	Parts Kit (included are keys 5, 9, 15, 19, ⁰0, 30 and 38). Screen is stainless steel and gaskets are composition and neoprene.	
	Type 289A (includes only keys 5 and 9)	
	Neoprene diaphragm	R289A X00012
	Type 289L (includes only keys 5, 9, and 15)	
	Nitrile diaphragm and O-rings	
	3/4-inch body	R289L X00012
	1-inch body	R289L X00022
	Type 289H (1-inch body) and 289HH	
	Nitrile diaphragm and O-rings	R289H X00012
	Fluoroelastomer diaphragm and O-rings	R289H X00032
	Type 289H, 2-inch body (includes keys 5, 9, 15, 19, 20 and 38)	
	Nitrile diaphragm and O-rings	R289H X00022
	Fluoroelastomer diaphragm and O-rings	R289H X00042
	Type 289U (includes only keys 5 and 9)	
	Nitrile diaphragm	R289U X00012
1	Valve Body	
	Type 289A, zinc	0Y0710 44022
	Type 289U, zinc	1B0438 44012
	Types 289H (1-inch body) and 289HH, Aluminum	3U8882 08012
	Type 289H (2-inch body), cast iron	31B1992 X012
	Type 289L, aluminum	
	3/4-inch body	3L4070 08012
	1-inch body	3L4069 08012
2	Spring Case/Spring Case Assembly	
	Type 289A, zinc	1A5051 44022
	Types 289H (1-inch body) and 289HH, Aluminum	1P9017 08012
	'ype 289H (2-inch body), zinc/steel	1E7020 000A2
	ype 289L, aluminum	3L3338 X0012
	Type 289U, zinc	0B0616 44022

Key	Description	Part Number
3	Diaphragm Head	
	Type 289A, zinc	0T0227 44022
	Type 289H, plated steel	
	1-inch body	1D6664 28982
	2-inch body	0W0202 25072
	Type 289HH, zinc plated steel	1P9014 25062
4	Spring Seat	
	Type 289A, brass	0T0226 14012
	Type 289U, zinc	1B3725 44022
	Types 289H (1-inch body) and 289HH, Plated steel	1D6671 25072
5*	Diaphragm/Diaphragm Assembly	
	Type 289A, neoprene	1A5052 02102
	Types 289H (1-inch body) and 289HH	
	Nitrile	1E6066 02052
	Fluoroelastomer	1E6066 02342
	Type 289H (2-inch body)	
	Nitrile	1D7800 02052
	Fluoroelastomer	1D7800 02332
	Type 289L	
	Nitrile(1)	
	3/4 & 1-inch body, standard	AL4068 000A2
	Fluoroelastomer(2) (1-inch body)	1N3130 X0012
	Type 289U(3), nitrile	18A281 5X012
6	Adjusting Screw	
	Type 289A, brass	1A5684 14012
	Types 289H (1-inch body) and 289HH, plated steel	1D9954 48702
	Type 289H (2-inch body) zinc	1B5379 44012
	Type 289L, Delrin(4)	T10071 06642
	Type 289U, brass	0F0581 14012
7	Spring	See table 2
8	Machine Screw, plated steel	
	Type 289A (6 req'd)	1B7774 28982
	Types 289H and 289HH, 1-inch body (8 req'd)	1A3917 24052
	Type 289H, 2-inch body (8 req'd)	1A4078 24052
	Type 289L (8 req'd w/o wire seal, 7 req'd w/wire seal)	1B2856 28982
	Type 289L (1 req'd w/wire seal)	1L9277 28982
	Type 289U (6 req'd)	1A3451 28982
9	Screen, Stainless steel	
	Type 289L	
	3/4-inch body	1B6335 38392
	1-inch body	1E5648 43122
	Types 289A and 289U	0L0783 43062
	Types 289H and 289HH, 1-inch body	1E5648 43122
	Type 289H, 2-inch body	11B1994 X012
10	Orifice	
	Type 289A, Aluminum	0T0225 09012
	Type 289H (2-inch body)	
	Brass	1E7026 13012
	Stainless steel	1E7026 35072
	Type 289L	
	Aluminum	1L4064 09012
11	Hex Nut	
	Types 289A and 289U, Brass	1A5054 18992
	Types 289H (1-inch body) and 289HH, Zinc plated steel	1D6677 28982
	Type 289H (2-inch body), Zinc plated steel	D7801 24272
13	Snap Ring	
	Type 289L, Stainless steel	
	3/4-inch body	1B6336 38992
	1-inch body	1E5649 37022

* Recommended spare part.
1. Assembly also includes an aluminum pitot tube and brushing, a zinc plated steel spring seat and diaphragm head, and a neoprene seat pad.
2. Assembly also includes an aluminum pitot tube, bushing, and diaphragm head, a 302 stainless steel spring seat, and a neoprene seat pad.
3. Assembly also includes a zinc diaphragm head.
4. Trademark of E.I. duPont de Nemours Co.

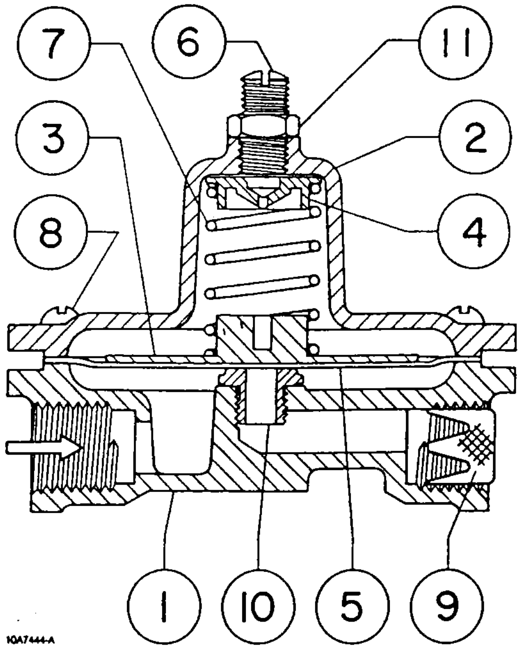


Figure 4. Type 289A Relief Valve

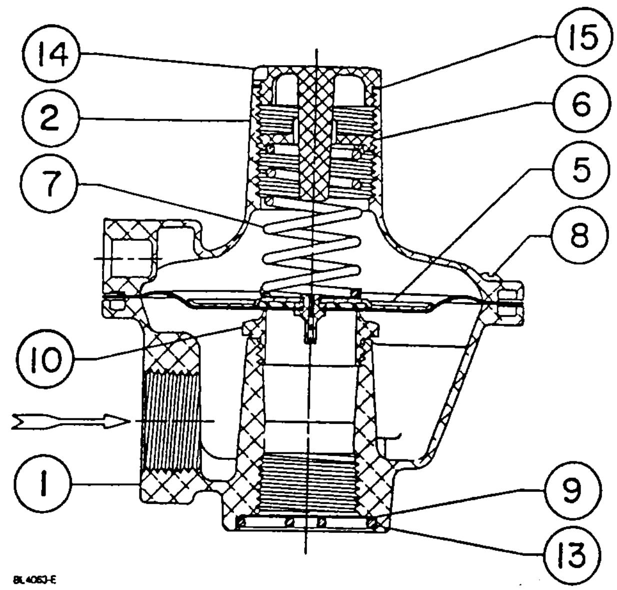


Figure 6. Type 289L Relief Valve

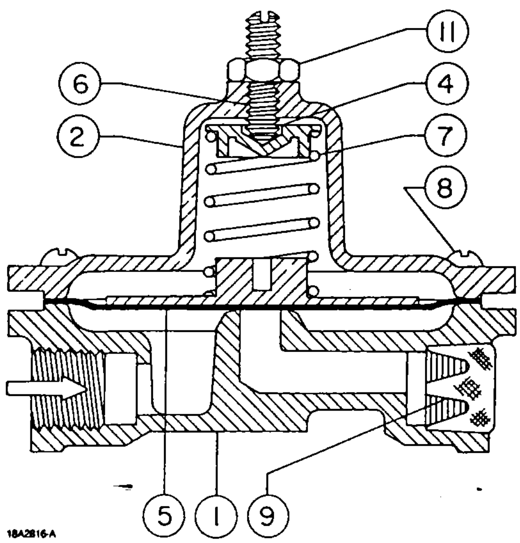


Figure 5. Type 289U Relief Valve

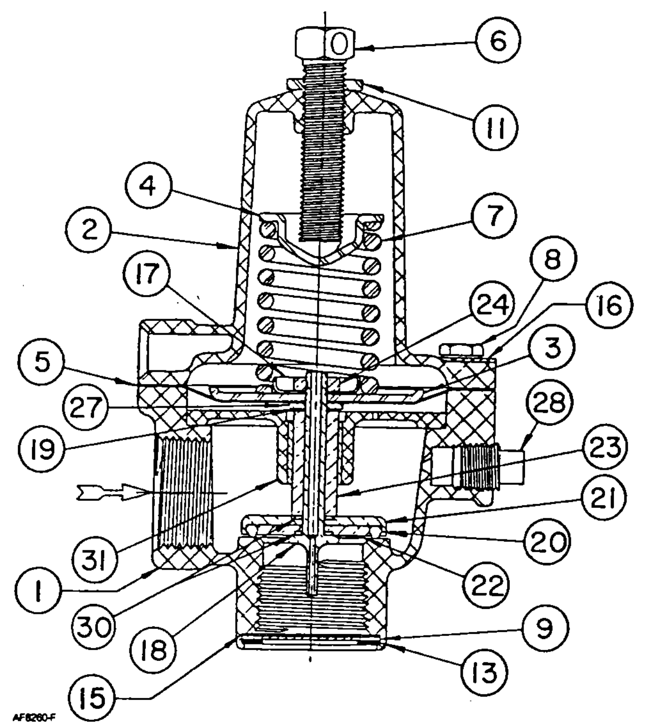


Figure 7. Typical of Type 289HH and 1-Inch Type 289H Relief Valves

Key	Description	Part Number
13	Snap Ring (Cont.)	
	Types 289H and 289HH, 1-inch body	
	Plated steel	13A993 8X012
	Type 289H, 2-inch body	10B9241 X012
14	Closing Cap	
	Type 289H, 2-inch body, zinc	1B5416 44012
	Type 289L	
	W/o wire seal, plastic	T10072 06992
	W/o wire seal, zinc	1H9669 X0012

Key	Description	Part Number
15*	Gasket	
	Types 289H and 289HH, 1-inch body	
	Neoprene	13A9929 X012
	Type 289H, 2-inch body	
	Neoprene	1P7533 06992
	Type 289L	
	Neoprene	1E1056 06992
16	Nameplate, aluminum	
	Types 289H and 289HH, 1-inch body	1F8527 11992

*Recommended spare part.

Key	Description	Part Number
17	Lower Spring Seat	
	Types 289H and 289HH, 1-inch body	
	Plated steel	1D6666 25072
	Type 289H, 2-inch body, zinc plated steel	1D7799 25062
18	Pitot Tube	
	Types 289H and 289HH, 1-inch body	
	Aluminum	1F8262 09012
	Type 289H, 2-inch body	
	Brass	1E7019 14012
	Stainless steel	1E7019 35032
19*	Gasket, composition	
	Type 289HH, 1-inch body (1 req'd)	1F8268 04022
	Type 289H, 2-inch body (3 req'd)	1D7798 04022
20*	O-Ring	
	Type 289H, 1-inch body	
	Nitrile	1F8266 06992
	Fluoroelastomer	1F2692 X0012
	Type 289H, 2 in. body	
	Nitrile	1P3361 06992
	Fluoroelastomer	1V6646 06382
	Type 289HH	
	Nitrile	1F2692 06992
	Fluoroelastomer	1F2692 X0012
21	O-Ring Holder, aluminum	
	Types 289H and 289HH, 1-inch body	1F8264 09012
22	O-Ring Washer	
	Types 289H and 289HH, 1-inch body	
	Aluminum	1F8265 09012
	Types 289H, 2-inch body, stainless steel	1E7021 36072
23	Spacer	
	Types 289H and 289HH, 1-inch body	
	Stainless steel	1F8263 35242
	Type 289H, 2-inch body	
	Brass	1E7022 14172
	Stainless steel	1E7022 35162
24	Hex Nut, plated steel	
	Types 289H and 289HH, 1-inch body	1A4997 24122
	Type 289H, 2-inch body	1B2282 28982
25	Lifting Stem, plated steel	
	Type 289H, 2-inch body	1D7802 24092
26	Lower Diaphragm Head, plated steel	
	Type 289H, 2-inch body	1E7031 25072
27	Washer, aluminum	
	Types 289H and 289HH, 1-inch body	1F8267 09012
	Type 289H, 2-inch body	1C6805 11032
28	Pipe Plug, plated steel	
	Types 289H and 289HH	1D7548 28982
29	Machine Screw, plated steel (not shown)	
	Types 289H and 289HH	
	1-inch body (2 req'd)	1D3869 28982
	Type 289H, 2-inch body (4 req'd)	1F3865 28992
30*	O-Ring (2 req'd)	
	Types 289H and 289HH, 1 in. body	
	Nitrile	1D6875 06992
	Fluoroelastomer	1N4304 06382

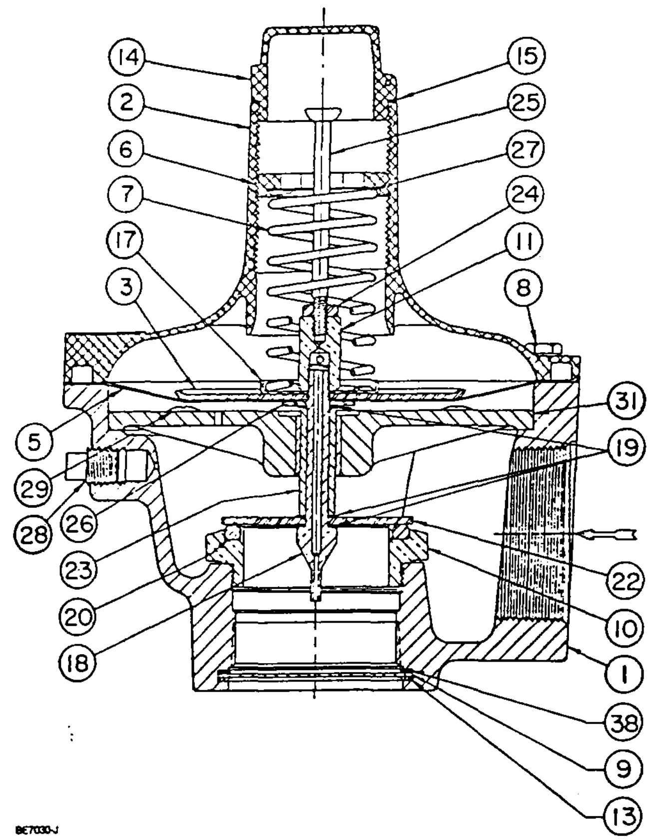


Figure 8. 2-Inch Type 289H Relief Valves

Key	Description	Part Number
31	Stem Guide Assembly	
	Type 289HH, 1-inch body	
	Zinc/brass	1F8272 000A2
	Zinc/303 stainless steel	1F8272 X0012
	Type 289H, 2 in. body	
	Cast iron/brass	1E7028 000A2
	Cast iron/303 stainless steel	1E7028 X00A2
32	Lifting Lever (not shown)	
	Type 289H, 2-inch body	0R0617 25092
33	Wire Seal (not shown)	
	Type 289L, 1-inch body	1D8847 99012
34	Diaphragm Protector (not shown)	
	Types 289A and 289U	10A511 6X012
38*	Gasket, Type 289H, 2-inch body	11B1993 X012

*Recommended spare part.

For information, contact Fisher Controls:
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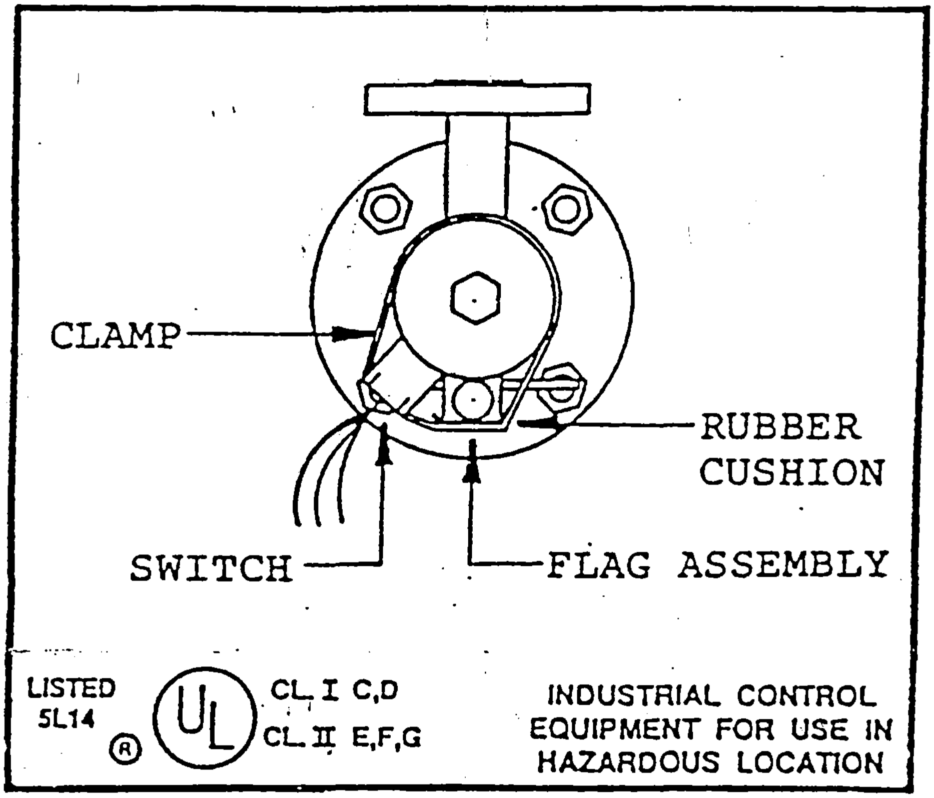
SPDT LATCHING SWITCH PART #9958



INSTALLATION INSTRUCTIONS FOR USE WITH 3" MLG GAUGE HOUSING PIPE

THE SWITCH SHOULD BE POSITIONED NEXT TO THE FLAG ASSEMBLY AS SHOWN. MOUNT THE SWITCH SO THAT THE 1/2" FNPT CONDUIT CONNECTION IS ABOVE THE CLAMP. THE SWITCH SUPPORT SHOULD PASS OVER THE SWITCH HOUSING AND THE FLAG ASSEMBLY AND AROUND THE PIPE. BEFORE TIGHTENING THE CLAMP, PLACE THE RUBBER CUSHION BETWEEN THE FLAG ASSEMBLY AND THE CLAMP TO PREVENT DAMAGE TO THE FLAG ASSEMBLY. SWITCHES CAN BE LOCATED AS CLOSE AS 3-1/4" FROM EACH OTHER (END TO END).

(SEE OTHER SIDE FOR SWITCH SPECIFICATIONS AND WIRING COLOR CODE.)

KENCO ENGINEERING
P.O. DRAWER 470426 TULSA, OKLAHOMA 74147
INWATS 1-800-331-7453 OKLAHOMA (918) 663-4406 TELEFAX (918) 663-4480

MAGNETIC LEVEL GAUGE INSTALLATION INSTRUCTIONS

CAUTION: DO NOT CUT, REMOVE, OR DAMAGE THE CLEAR PROTECTIVE COVERING ON THE MAGNETIC FLAG ASSEMBLY. DAMAGE TO THIS COVERING MAY CAUSE IMPROPER OPERATION.

ISOLATION VALVES ARE RECOMMENDED BETWEEN THE GAUGE HOUSING AND THE PROCESS CONNECTION. THIS ALLOWS MAINTENANCE AND INSPECTION ACTIVITIES TO TAKE PLACE WITHOUT DRAINING THE PROCESS TANK.

ALL PROCESS CONNECTIONS SHOULD BE MADE UP USING GASKETS AND/OR THREAD SEALANTS COMPATIBLE WITH THE APPLICATION.

MAKE UP ALL PROCESS CONNECTIONS LOOSELY. TIGHTEN ONLY AFTER ALL CONNECTIONS AND FASTENERS ARE IN POSITION.

AFTER ALL PROCESS CONNECTIONS ARE MADE UP, REMOVE LOWER FLANGE (NOT APPLICABLE TO MLG-D) TO INSTALL THE FLOAT. INSERT THE FLOAT INTO THE GAUGE HOUSING WITH THE "TOP" LABEL TOWARDS THE TOP OF THE HOUSING AND THE "FLAG" LABEL TOWARDS THE FLAG ASSEMBLY.

NOTE! CORRECT OPERATION OF THE GAUGE DEPENDS ON THE CORRECT ORIENTATION OF THE FLOAT. RE-ATTACH THE LOWER FLANGE AND GASKET TO THE GAUGE HOUSING.

ATTENTION **READ BEFORE USING** **ATTENTION**

WARRANTY:

New Procon pumps manufactured in November, 1993 and later are warranted to be free of defects in workmanship and materials for a period of 24 months from the date of factory shipment. Factory rebuilt Procon pumps are warranted to be free of defects in workmanship and materials for a period of 12 months from the date of factory shipment. Defective pumps will be rebuilt or replaced provided they are returned to Procon intact, freight prepaid and our inspection substantiates the claim.

RRANTY VOID IF:

Pump has been opened or dismantled in any fashion.
2. Foreign matter (i.e. abrasive particulate) has passed through the pump.
3. Non compatible liquids have been passed through the pump.
4. Pump was operated dry or was subjected to cavitation.
5. Pump operated at discharge pressures in excess of 250 PSI.

*Special alert for those pumps which contain the integral relief valve - this valve should not be used as a flow or pressure regulator. This valve is designed to be a safety feature to prevent system damage. Continuous or frequent use of the valve may result in degraded pump performance and/or void the warranty.
All fittings should be removed from the pump before returning to Procon Products for rebuilding! Procon cannot be held responsible for the return of fittings, gauges and other accessories accompanying the pump. Pumps being returned for rebuilding should be packaged carefully to prevent damage in shipping.

Following are some suggestions for installing your Procon pump. If further instruction is needed feel free to call our factory and we will be glad to answer any questions.

Catalogs are available upon request.

An explanation of the warranty can be found on the back side of the invoice.

NOTICE: Your pump can be ruined or its service life shortened if these operating conditions aren't met at all times.

- Pumps must have a fluid supply to the pump inlet greater than the pump's flow rating.
- Fluid must be compatible with the pump.
- Fluid must not contain any particles.
- Pump must not operate above 250 PSI.
- id flow should not stop nly while the pump is ing.
- Operating pressure should be 50 PSI below Procon's relief valve setting.
- If using compressed air to purge the pump of fluid, install a coalescing filter in the air system to prevent contaminated air from entering the pump.

We suggest that you use the precautionary measures and piping layout that follow. This layout promotes a long trouble-free life for your pumps.

SOLENOID VALVES

If you use solenoid valves in conjunction with Procon pumps, take the following precautions to prevent serious over/under pressurization.

If you can incorporate a time delay into the control circuit to turn off the pump motor and allow it to stop prior to the closing of the solenoid valve, then you can put the solenoid valve on either the inlet or the discharge of the pump. Also, the time delay should allow time for the solenoid valve to fully open prior to starting the pump motor.

If a time delay is not possible, locate the solenoid valve on the discharge side of the pump downstream of the relief valve.

If it is possible that the pump in your system may experience a sudden blockage of the discharge, then a customer supplied external by-pass valve should be installed on the discharge line and set to a maximum of 250 psi.

At this recommended setting, the by-pass valve should prevent sudden over-pressurization. If the discharge becomes blocked, the by-pass valve will bypass the fluid from the discharge line back to the reservoir or inlet line. Piping length should be long enough to allow heat dissipation and prevent the pump from overheating.

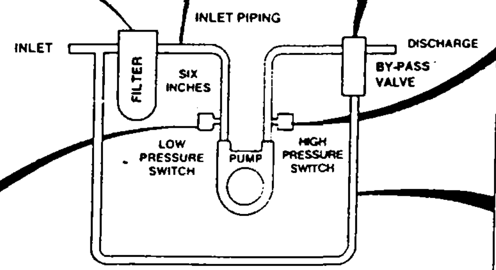
If particles may contaminate the fluid, use a particulate filter that is capable of filtering particles larger than 125 microns. If the particles are abrasive, use a filter that is capable of removing virtually all of the particles.

Make sure there is at least 6 inches of piping between the pump inlet and any "T-fitting," elbow, or system component to minimize turbulence. The piping should be made from a material that does not corrode or shed particles. A flexible hose of plastic, copper, or stainless steel are good choices, among others. Be sure no joint compound or tape falls into the inlet of the pump.

The inlet piping should have a minimum interior diameter of
- 3/8 inch for series 1, 2, and 3 pumps
- 1/2 inch for series 4 & 5 pumps
- 1 inch for series 6 pumps

If it is possible that the pump in your system may experience too much discharge back pressure, install a pressure switch set to 250 psi.

Mount or port this pressure switch close to the pump outlet. If the outlet pressure rises too high while the pump is operating, the switch will shut the pump motor off. By shutting the motor off, this switch will help protect the pump from over-pressurization.



If it is possible that the pump in your system may experience insufficient fluid supply (low flow rate), install a pressure or suction switch to prevent cavitation. This switch should be mounted or ported close to the pump inlet. Series 1, 2, 3, 4 and 5 may operate with as much as 6 feet of suction lift, with the exception of the 330 GPH models, which require a minimum of 20 PSI inlet pressure. Series 6 must have positive inlet pressure.

If the inlet pressure falls too low while the pump is operating, the switch will shut the pump motor off. By shutting the motor off, this switch helps protect the pump from cavitation due to an insufficient fluid supply or a plugged filter.

As shown, the by-bass flow is directed to the inlet feed line. However, if your system is operating from a feed reservoir, we recommend by-passing any flow of the relief valve directly back into the reservoir, rather than back into the inlet feed line. If the inlet feed line is used, introduce the by-pass flow at least 12 inches upstream of the pump inlet port.

PROCON PRODUCTS
A Division of Roehlen Industries
a Standex company
910 Ridgely Road • Murfreesboro, Tennessee 37129
Telephone: (615)890-5710 • Fax: (615)896-7729
Procon Form 151 04-97 *"Quality Products - Delivered On Time"*
nsai I.S. EN ISO 9001

Installing Your PROCON Pump

Your Procon pump is a precision-built piece of equipment. Handle it carefully. Procon pumps should be installed only by qualified technicians.

> **NOTICE**
> When you install your pump, follow these guidelines:
>
> • Do not hammer or mishandle your pump.
>
> • Keep all foreign materials out of your pump.
>
> • Never vise or grip the round body portion of the pump housing. Grip only the square inlet/outlet bosses when you install fittings. Always support the pump when you install fittings to avoid bending the V-band clamp even if the pump is already mounted to the motor.
>
> • Make sure the power is off before working with an electric motor. If possible, lock out the power at a disconnect.
>
> • Make sure you have an adequate, well-lit work space and use the correct tools.
>
> • Do not use any components that are damaged or deformed. You should not have to force any parts together. If you receive parts that are damaged or deformed, call your Procon factory representative.

We test every Procon pump at the factory for pressure and flow. If the pump has a relief valve, we set it to your specifications.

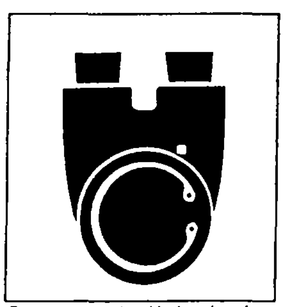
> **CAUTION**
> Do not tamper with the relief valve on your pump. If you think the relief valve needs to be reset, contact your Procon factory representative.

We make every effort to ensure that your pump is of the highest quality. To get the most out of your pump, read and follow these instructions carefully.

For all motors-- examining your pump *BEFORE* you get started

Before you install your pump, you must carefully unpack the pump and examine and prepare it to be installed. Follow these steps for all types of motors.

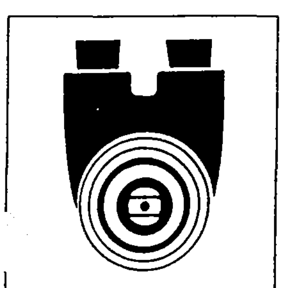
> **NOTICE**
> Do not exchange one pump model for another. Pumps are carefully engineered to meet specific requirements and flow rates.
>
> All pumps within a series have the same housing. The may look alike, but they perform differently. Check the model number to make sure you have the correct pump before you install it.
>
> Using the wrong pump may damage your pump, your system, or your electric motor.



Do not remove the shipping plugs from the ports at the top of the pump until time to install fittings.

1. TAKE THE PUMP OUT OF ITS SHIPPING CONTAINER.
Do not remove the shipping plugs from the port until the fittings are ready to be installed. This will keep debris out of the pump.

If the pump has a shaft coupling, remove the coupling and discard the foam shipping strip. Reinsert the coupling.
Be careful when handling the pump; do not drop it or bang it. If you mishandle the pump, especially the shaft end, you can disrupt or damage internal clearances and impair performance of your pump.



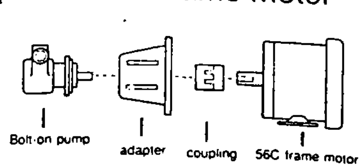
Examine the mounting surfaces on the pump.

2. EXAMINE THE MOUNTING SURFACES.
Carefully remove any burrs or raised metal which may have occurred during unpacking and handling to make sure the pump will sit and be aligned properly.

Now you are ready to mount the pump to a motor. Procon pumps work with two types of electric motors-- a carbonator style motor (NEMA 48YZ frame) and a C-frame motor (NEMA 56C frame). Follow the steps for the type of motor you are using.

Mounting your pump on a 56C frame motor

You should have these parts:
• bolt-on Procon pump
• Procon motor adapter
• 3-piece drive shaft coupling
. 56C frame motor



Correctly assembling the coupling and the adapter, and mounting the pump is a trial and error process. You may have to try several times before you get it right.
FOLLOW THESE STEPS AFTER YOU HAVE EXAMINED YOUR PUMP.

1. Mount the drive shaft coupling.
a. Make sure motor is electrically disconnected and cannot accidently turn on.
b. Mount the half of the coupling for the motor onto the motor shaft and tighten the set screw.
c. Insert the elastomer piece onto the motor piece.
d. Mount the half of the coupling for the pump onto the pump shaft, but do not tighten the set screw.
Make sure the coupling slides easily onto the pump and the motor shaft--do not force it. Make sure the shaft does not protrude into the space occupied by the elastomer piece. The series 6 pump requires a shaft key.

2. Mount the motor adapter onto the motor using four 3/8 inch dia. by 1 inch long bolts (16 threads/inch) and lock washers.
Rotate the pump to orient the inlet/outlet ports as desired.

3. Mount the pump onto the motor adapter while simultaneously engaging the coupling pieces.

4. Check to make sure that the coupling is properly engaged.

5. Tighten the set screw on the pump coupling half.

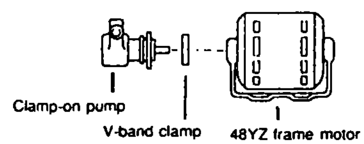
6. Check your assembly.
The elastomer coupling piece should have about 1/16 inch of play between the two metal pieces.
If it does, go to step 7.
If it does not, repeat steps 1 through 5, until the assembly is correct.

7. Fasten the pump to the adapter using three 1/4 inch dia. by 3/4 inch bolts (20 threads/inch) and lock washers or two 3/8 inch dia. by 1 inch bolts (16 threads/inch) for series 6.

8. Check to make sure that your motor rotates correctly.
Motor rotation must correspond to the rotation arrow on the nameplate of the pump.

Mounting your pump on a 48YZ frame motor

You should have these parts:
• Clamp-on Procon pump
• Procon V-band clamp
• 48YZ frame motor



AFTER YOU HAVE EXAMINED YOUR PUMP FOR DAMAGE, FOLLOW THESE STEPS.

1. Make sure motor is electrically disconnected and cannot accidently turn on.

2. Slip the V-band onto the motor ring flange.

3. Mount the pump to the motor by inserting the tang (shaft) of the pump into the slot on the motor.

4. Rotate the pump to orient the inlet/outlet ports as desired.

5. Make sure the ring flanges on the pump and on the motor are properly engaged and flush against one another.

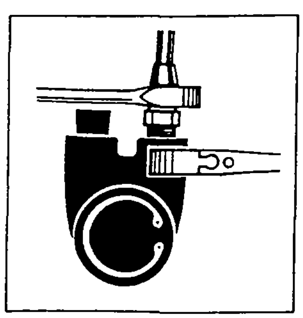
6. Make sure the clamp is fully seated around the entire circumference of the pump and motor flanges.

7. Tighten the V-band clamp using 15 to 30 inch-pounds of torque.

NOTE: Do not over tighten the clamp. The V-band clamp is designed to support the pump and fittings only. Loads caused by rigid plumbing or heavy attachments may result in misalignment.

For all motors--installing the plumbing

When you finish mounting your pump on a motor, you must install the plumbing for the pump. Follow these steps after you have mounted your pump.



Use a backup wrench on the square port boss to support the pump.

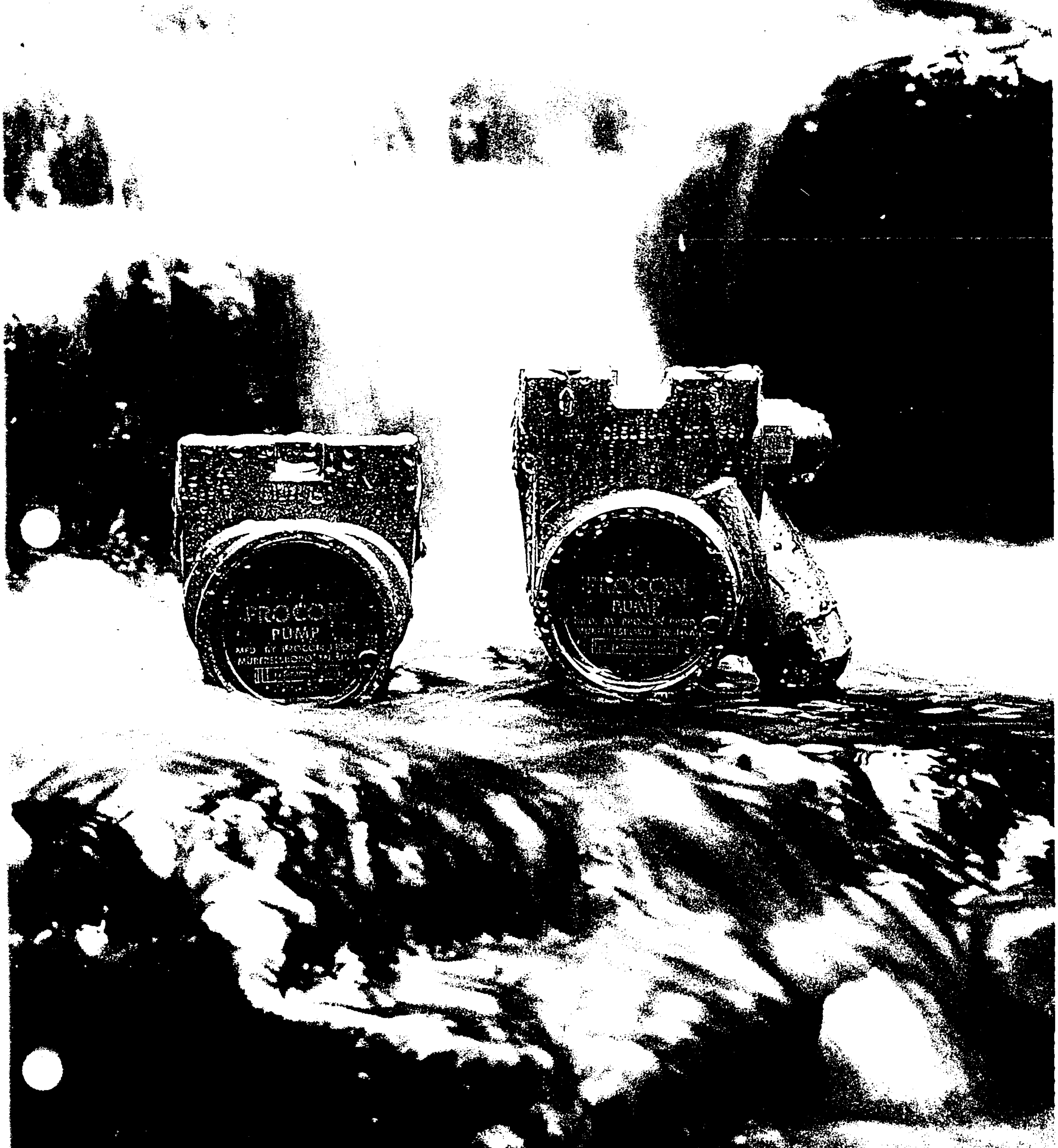
1. INSTALL THE INLET AND OUTLET FITTINGS.
Support the pump by using a backup wrench on the square port bosses. Do not put any strain on the V-band clamp.
Use brass fittings or plastic fittings on a brass pump. Use stainless steel or plastic fittings on a stainless steel pump. Using dissimilar metals can cause corrosion, which may get into the pump and cause damage.
Use teflon thread tape to install the fitting. Do not let any thread tape get into the pump and do not overtighten the fittings

2. CHECK THE INLET LINE.
Make sure that the inlet line is big enough to allow adequate flow to the inlet port of the pump (3/8 inch dia. ID for series 1, 2 and 3; 1/2 inch dia. ID for series 4 & 5; 1 inch dia. ID for series 6)
Make sure that the inlet line is clean and properly flushed out.
Protect the pump with a 100 mesh or finer strainer or filter.

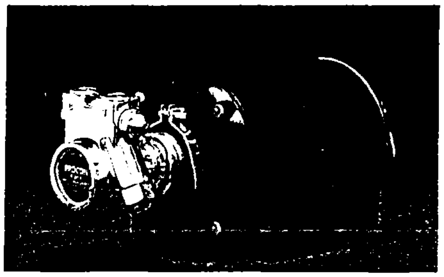
3. CONNECT THE INLET LINE TO THE FITTING ON THE PUMP.

4. CONNECT THE OUTLET LINE TO THE FITTING ON THE PUMP.

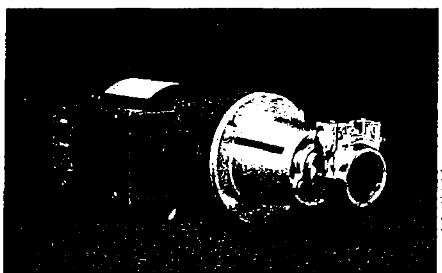
PROCO



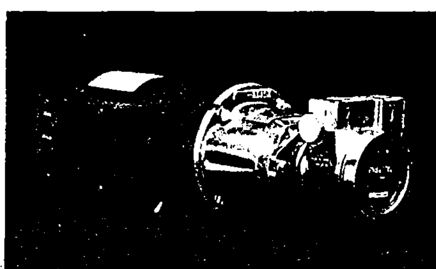
PRECISION CRAFTED POSITIVE DISPLACEMENT PUMPS



SERIES 1, Clamp-on Type
with NEMA 48YZ frame motor



SERIES 4, Bolt-on Type
with NEMA 56C frame motor



SERIES 6, Bolt-on Type
with NEMA 56C frame motor

PROCON PRO

A Division of Roehlen Industr

910 Ridgely Road • Murfreesboro, TN 37129 USA

Telephone 615•890•5710

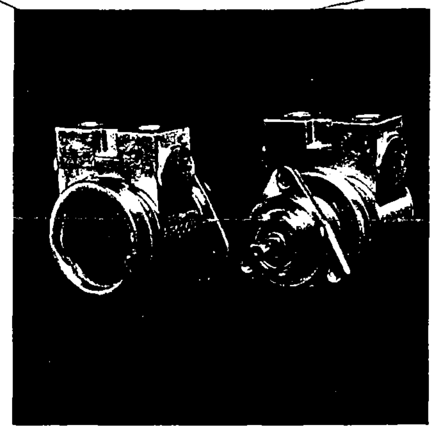
FAX 615•896•7729

a Standex company

CATALOGUE 3004

PRINTED 1997

Series 4 & Series 5:

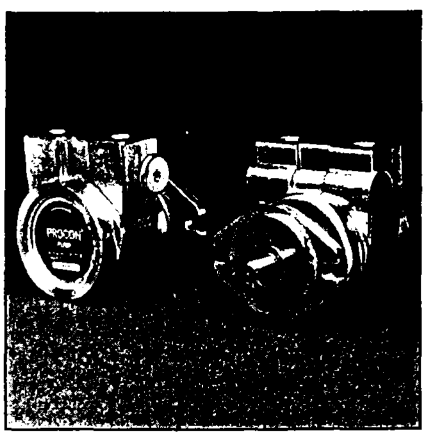


PROCON's Series 4 & 5 are designed and built to meet your needs for flow rates ranging from 115 to 330 gallons per hour at 250 psi. These PROCON pumps maintain all the quality features and construction of our Series 1, 2, & 3 pumps. Bolt-on mounting style is shown in the photo; clamp-on style is also available.

Standard specifications:

Body (Series 4) . . . . brass
(Series 5) . . . stainless steel
Capacity . . . . 115 to 330* gph
Nominal speed . . . . 1,725 rpm
Max. discharge pressure . 250 psi
Rotation . . . . clockwise
Dry weight . . . . approx. 4.5 lbs
Self priming (water) . . 6 ft max. lift*
* (330 GPH model requires min. 20 psi inlet pressure)

Series 6



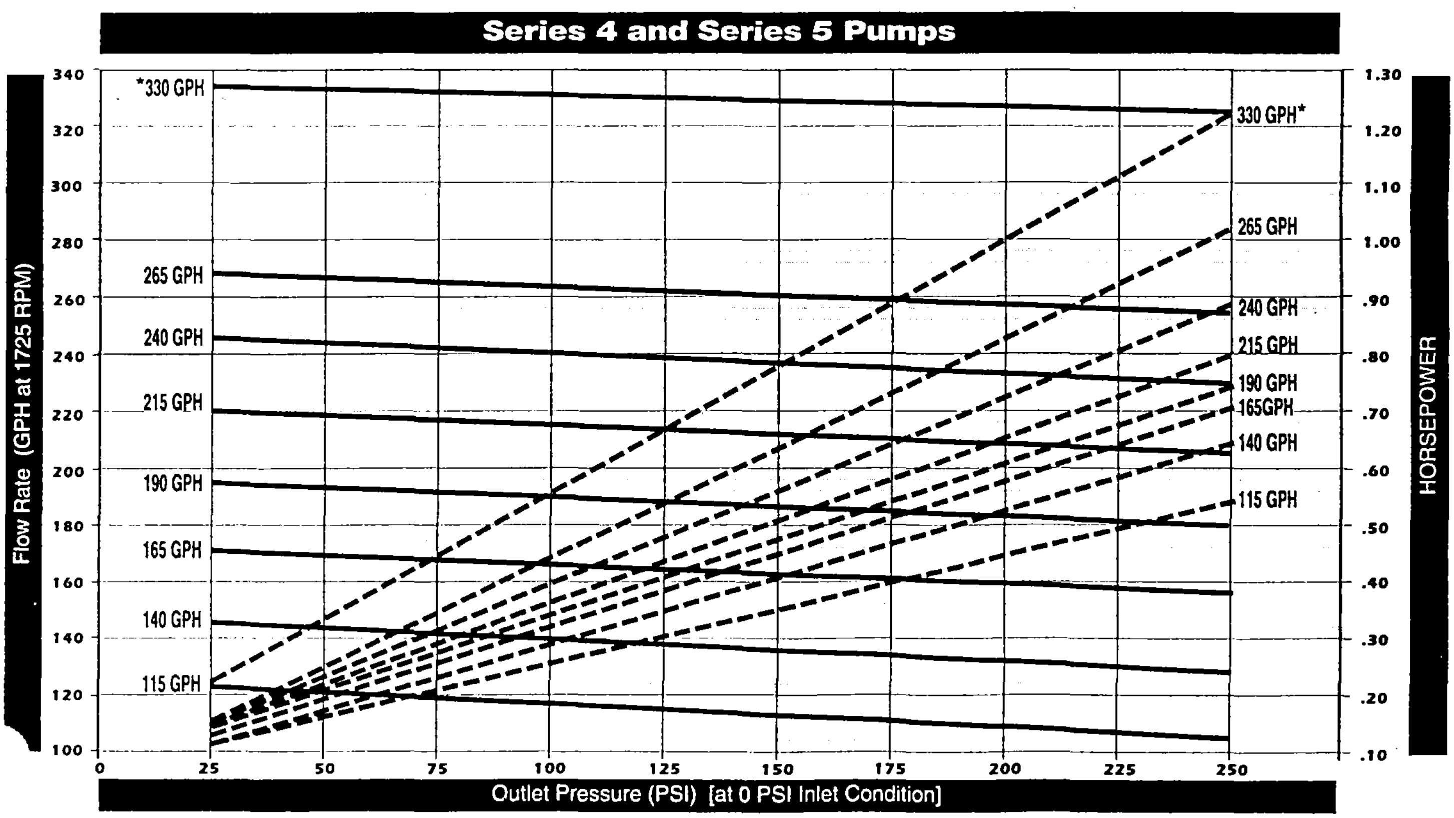
PROCON's Series 6 is designed and built to meet your needs for higher flows. The flow rate capacity for this pump ranges from 300 to 660 gallons per hour at 250 psi. This series pump is available only in bolt-on style. No integral relief valve is available.

Standard specifications:

Body . . . . stainless steel
Capacity . . . . 300 to 660 gph
Nominal speed . . . . 1,725 rpm
Max. discharge pressure . 250 psi
Rotation . . . . clockwise
Dry weight approx. 15 lbs
Minimum inlet pressure . . flooded
(no inlet suction lift allowed)

NOTE: Specifications and dimensions are subject to change without notice.

Series 4 & 5 Nominal Volume at 1725 RPM										
Flow Rate (GPH)	Gallons Per Hour					Brake Horsepower				
	Pressure (PSI)					Pressure (PSI)				
	50	100	150	200	250	50	100	150	200	250
330	331	330	328	327	326	0.33	0.55	0.78	1.00	1.22
265	265	263	261	259	257	0.24	0.43	0.63	0.82	1.01
240	243	240	236	232	228	0.21	0.37	0.54	0.70	0.86
215	218	215	211	207	203	0.20	0.35	0.50	0.65	0.80
190	193	190	186	182	178	0.18	0.33	0.47	0.61	0.75
165	168	165	161	157	153	0.17	0.30	0.43	0.57	0.70
140	143	140	136	132	128	0.16	0.28	0.40	0.52	0.64
115	118	115	111	107	103	0.15	0.25	0.35	0.45	0.55



Flow Rate vs. Outlet Pressure ———— **Horsepower vs. Outlet Pressure** - - - - -

*330 GPH - 20 psi inlet required

OPERATIONS AND MAINTENANCE MANUAL
MULTIPHASE RECOVERY SYSTEM
FUEL FARM 216
NAS CORPUS CHRISTI, TEXAS

ATTACHMENT 6

BAG FILTER (F-1)

Standard Filter Vessel Models

Model No.	No. of Bags	Bag Size No.	Surface Area Per Bag, Ft.^{2}	Surface Area Per Vessel, Ft.^{2}	Inlet & Outlet Size	Max. Flow Rate, GPM*
FSP-20	1	3	0.5	0.5	1"	25
FSP-35	1	4	1.0	1.0	1"	45
FSP-40	1	1	2.0	2.0	2"	90
FSP-85	1	2	4.4	4.4	2"	200
FSP-250	2	2	4.4	8.8	3"-4"	400
FSP-350	3	2	4.4	13.2	3"-6"	600
FSP-800	4	2	4.4	17.6	4"-6"	800
FSP-1000	5	2	4.4	22.0	4"-8"	1000
FSP-1100	6	2	4.4	26.4	4"-8"	1200
FSP-1300	7	2	4.4	30.8	6"-8"	1400
FSP-2000	8	2	4.4	35.2	8"-10"	1600
FSP-2500	10	2	4.4	44.0	8"-10"	2000
FSP-3000	12	2	4.4	52.8	8"-10"	2400
FSP-3500	14	2	4.4	61.6	10"-12"	2800
FSP-4000	16	2	4.4	70.4	10"-12"	3200
FSP-4200	18	2	4.4	79.2	10"-14"	3600
FSP-4500	20	2	4.4	88.0	10"-14"	4000
FSP-4800	22	2	4.4	96.8	10"-14"	4400
FSP-5000	24	2	4.4	105.6	10"-14"	4800

*Maximum flow rate is based on aqueous flow at 1.0 PSI ΔP clean. Inlet and outlet pipe sizes can be changed to meet customer requirements.

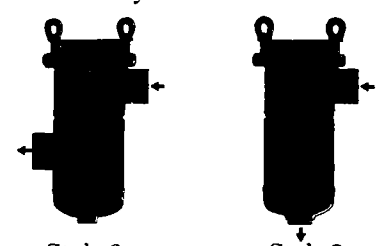
BFN Vessels

[illegible]

[illegible]

These vessels are available [illegible] and 316 S.S. is available on request.

Inlet/Outlet Styles Available



Style 6 – Side In/Side Out – Offset

Style 2 – Side In/ Bottom Out

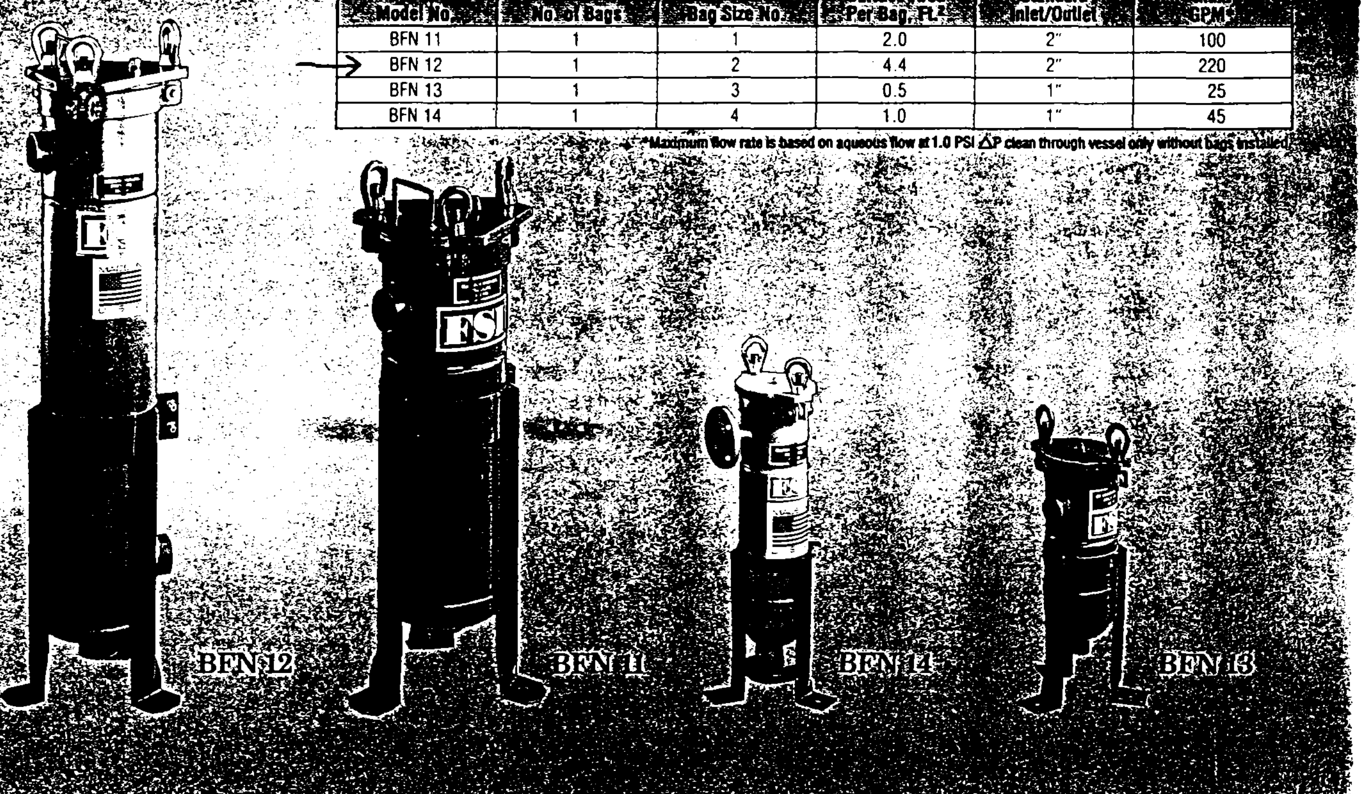
Standard Features

- Maximum working pressure:
  - BFN 11, 12 – 150 PSI
  - BFN 13, 14 – 150 and 300 PSI
- Single gasket cover seal
- Gasket materials available include Buna-N, Neoprene, EPR, Viton, Teflon (others on request)
- 304 S.S. perforated basket for up to 75 PSI differential
- Two inlet/outlet styles
- Same side inlet/outlet for easy manifolding
- Low pressure drops
- Variety of connections available [illegible] or flange:
  - BFN 11, 12 [illegible]
  - BFN 13, 14 [illegible]
- Permanently piped housing
- Available with steam jackets, extra length legs, corrosion allowances, evacuation float

BFN Vessels

Model No.	No. of Bags	Bag Size No.	Surface Area Per Bag, Ft.^{2}	Standard Inlet/Outlet	Max. GPM*
BFN 11	1	1	2.0	2"	100
BFN 12	1	2	4.4	2"	220
BFN 13	1	3	0.5	1"	25
BFN 14	1	4	1.0	1"	45

*Maximum flow rate is based on aqueous flow at 1.0 PSI ΔP clean through vessel only without bags installed.



BFN 12 BFN 11 BFN 14 BFN 13

FSI Advanced Design

FSI Bag Filter Vessels are designed, built and stamped to meet code requirements in our own ASME code manufacturing facilities. Features like the single-gasket seal, permanent piping and heavy-duty perforated metal baskets as standard equipment provide durable and consistent performance. Positive bag hold down is an integral part of the lid. Our advanced basket design eliminates the need for under-basket gaskets. Swing-out cover bolts with eyenuts simplify the bag-changing operation, while our (optional) Displacement Floats reduce spillage and ensure proper seating of the bag.

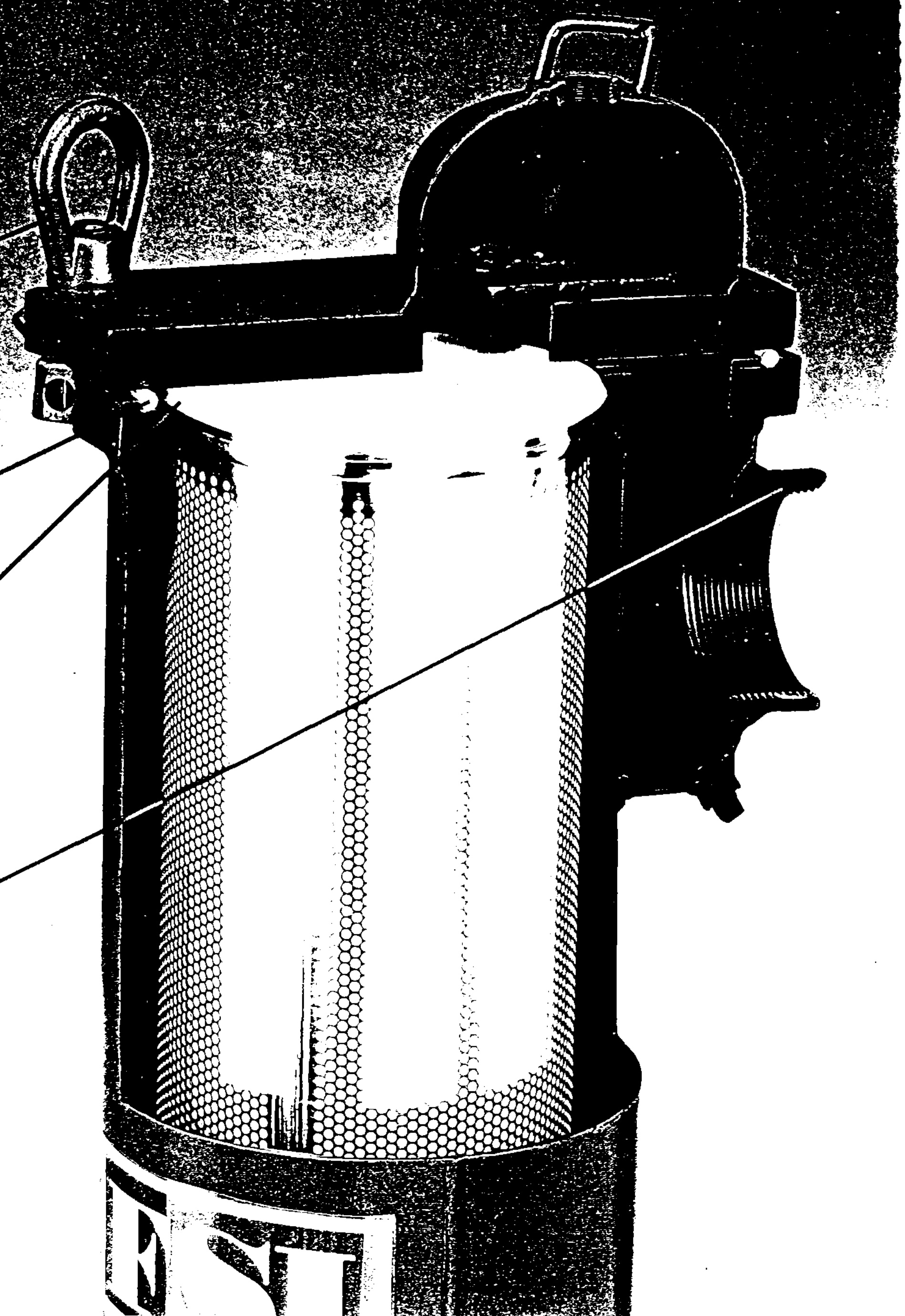
Of course, all FSI Bag Filter Vessels are fully compatible with conventional ring type bags as well as FSI Polyloc bags, which feature the most advanced sealing device on the market today.

Standard Features

- Completely cleanable; easy cleaning access
- Full ports for unrestricted flow
- Heavy duty baskets standard (no gasket required)
- Single gasket lid seal
- Positive bag sealing
- Carbon Steel or Stainless Steel housing standard

Options

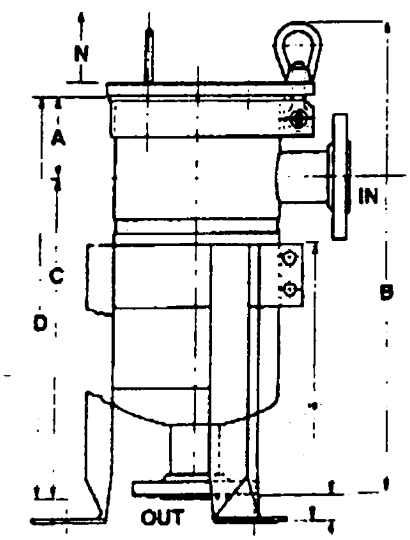
- Titanium, Hastelloy B&C, and Alloy 20 available on request.
- Coatings available

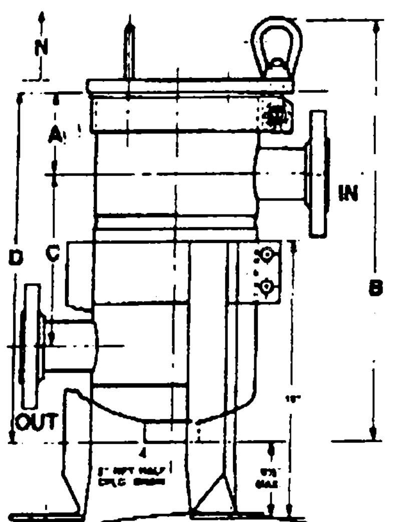


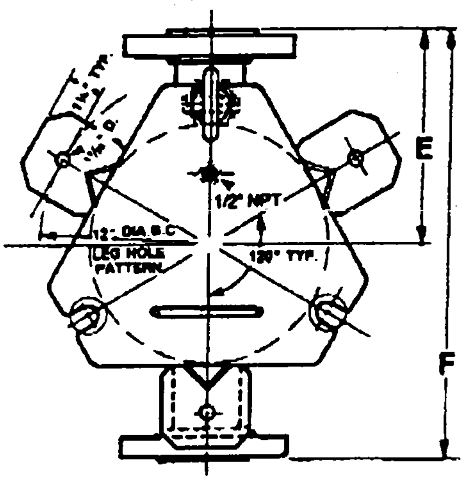
FSI® filter specialists, inc.
100 Anchor Road • P.O. Box 735 — Michigan City, Indiana 46360
219/879-3307 Telex: 25829

MODELS BFN-11
BFN-12

SINGLE BAG ORDER INFORMATION SHEET







STYLE 2 FLANGE FITTINGS SIDE INLET — BOTTOM OUTLET

STYLE 6 FLANGE FITTINGS SIDE INLET — SIDE OUTLET

TOP

BFN-11 (S or P)* Style 2

[illegible]	A	B	C	D	E	F	N
	4 5/8"	30 1/2"	22 3/4"	27 3/8"	8 1/4"	10 7/8"	16"
1 1/2"	4 5/8"	30 1/2"	22 3/4"	27 3/8"	8 1/4"	10 7/8"	16"
2"	4 5/8"	30 1/2"	22 3/4"	27 3/8"	8 1/4"	10 7/8"	16"
2 1/2"	4 7/8"	30 1/2"	22 1/2"	27 3/8"	8 1/4"	12 5/8"	16"
3"	5 1/4"	32 1/4"	23 7/8"	29 1/8"	8 1/4"	10 7/8"	16"
4"	5 3/4"	32 1/4"	23 3/8"	29 1/8"	8 1/4"	9 1/8"	16"

BFN-11 (S or P)* Style 6**

FLG	A	B	C	D	E	F	N
1"	4 5/8"	28 3/8"	14 1/4"	24 3/4"	8 1/4"	16 1/2"	16"
1 1/2"	4 5/8"	28 3/8"	14 1/4"	24 3/4"	8 1/4"	16 1/2"	16"
2"	4 5/8"	28 3/8"	14 1/4"	24 3/4"	8 1/4"	16 1/2"	16"
2 1/2"	4 7/8"	29"	14 1/4"	25 5/8"	8 1/4"	16 1/2"	16"
3"	5 1/4"	30 3/4"	14 1/4"	27 1/8"	8 1/4"	16 1/2"	16"
4"	5 3/4"	30 3/4"	14 1/4"	27 1/8"	8 1/4"	16 1/2"	16"

BFN-12 (S or P)* Style 2

FLG	A	B	C	D	E	F	N
1"	4 5/8"	45"	37 1/4"	41 7/8"	8 1/4"	10 7/8"	30"
1 1/2"	4 5/8"	45"	37 1/4"	41 7/8"	8 1/4"	10 7/8"	30"
2"	4 5/8"	45"	37 1/4"	41 7/8"	8 1/4"	10 7/8"	30"
2 1/2"	4 7/8"	45"	37"	41 7/8"	8 1/4"	12 5/8"	30"
3"	5 1/4"	46 3/4"	38 3/8"	43 5/8"	8 1/4"	10 7/8"	30"
4"	5 3/4"	46 3/4"	37 7/8"	43 5/8"	8 1/4"	9 1/8"	30"

BFN-12 (S or P)* Style 6**

FLG	A	B	C	D	E	F	N
1"	4 5/8"	42 7/8"	28 3/4"	39 1/4"	8 1/4"	16 1/2"	30"
1 1/2"	4 5/8"	42 7/8"	28 3/4"	39 1/4"	8 1/4"	16 1/2"	30"
2"	4 5/8"	42 7/8"	28 3/4"	39 1/4"	8 1/4"	16 1/2"	30"
2 1/2"	4 7/8"	43 1/2"	28 3/4"	39 7/8"	8 1/4"	16 1/2"	30"
3"	5 1/4"	45 1/4"	28 3/4"	41 5/8"	8 1/4"	16 1/2"	30"
4"	5 3/4"	45 1/4"	28 3/4"	41 5/8"	8 1/4"	16 1/2"	30"

*S - Snap Ring
P - Poly Loc™

Note: Designed to ASME Code. UM Stamp available as an option

**Dimension C can be varied on Style 4.

ORDER INFORMATION: Check appropriate boxes

Design Pressure: ☐ 100 PSIG ☐ 150 PSIG
☐ Other

Design Temperature (F°) ☐ Max. ____________ Min. ____________

Construction Material:
☐ Carbon Steel
☐ 304 Stainless Steel
☐ 316 Stainless Steel
☐ Other ____________

Basket Materials:
☐ 304 Stainless Steel (Standard)
☐ 316 Stainless Steel
☐ Other ____________

Gasket Material:
☐ Buna-N (Standard)
☐ Vitron
☐ Neoprene
☐ EPR
☐ Teflon Encapsulated
☐ Other ____________

Lifting Mechanism: ☐ Hinge is Standard

Ordering Information:

To order, use the abbreviations from the charts shown on this page. The charts are color coded for your convenience.

Single Bag Example:

	2				
FSP 85	2	304	150	2 FLG	COATED

These codes describe the following vessel: FSP-85 model no. – Inlet/Outlet Style 2, Side in/Bottom out – 304 stainless steel construction – 150 PSI pressure rating – 2 inch flange connection – Coated

Multi Bag Example:

	2				
FSP 2500	8	CS	150	INLINE	1/16 CA

These codes describe the following vessel: FSP-2500 model No. – 8 inch flange connection – Carbon steel construction – 150 PSI pressure rating – Inline Inlet/Outlet – 1/16" corrosion allowance

BFN Example:

	2					
BFN	P	12	6	304	150	2 FLG

These codes describe the following vessel: BFN model series – Polyloc bag style – holds one (1) #2 size bag – Inlet/Outlet Style 6, Side in/Side out, offset – 304 stainless steel construction – 150 PSI pressure rating – 2 inch flange connection

Single Bag

	2 Inlet/Outlet Style
FSP-20 FSP-35	1 – Side In/Side Out – Inline 2 – Side In/Bottom Out 6 – Side In/Side Out – Offset
FSP-40 FSP-85	1 – Side In/Side Out – Inline 2 – Side In/Bottom Out 3 – Side In/Bottom Out – 90° Elbow 6 – Side In/Side Out – Offset

CS – Carbon Steel
304 – 304 Stainless Steel
316 - 316 Stainless Steel

150 – 150 PSI
300 – 300 PSI
XXX – Customer Specified

FSP-20 & FSP-35	
1 NPT	1½ NPT
1¼ NPT	2 NPT
FSP-40 & FSP-85	
1 NPT	1 FLG
1¼ NPT	1¼ FLG
1½ NPT	1½ FLG
2 NPT	2 FLG
2½ NPT	2½ FLG
3 NPT	3 FLG
	4 FLG

5 Options
CA – Corrosion allowance
Coated
PSJ – Partial Jacket
FSJ – Full Jacket

Multi Bag

	2 Connection Size
FSP-250	3"-4" FLG
FSP-350	3"-6" FLG
FSP-800	4"-6" FLG
FSP-1000	4"-8" FLG
FSP-1100	4"-8" FLG
FSP-1300	6"-8" FLG
FSP-2000	8"-10" FLG
FSP-2500	8"-10" FLG
FSP-3000	8"-10" FLG
FSP-3500	10"-12" FLG
FSP-4000	10"-12" FLG
FSP-4200	10"-14" FLG
FSP-4500	10"-14" FLG
FSP-4800	10"-14" FLG
FSP-5000	10"-14" FLG

CS – Carbon Steel
304 – 304 Stainless Steel
316 – 316 Stainless Steel

100 – 100 PSI
150 – 150 PSI
300 – 300 PSI
XXX – Customer Specified

In line
Side out

5 Options
CA – Corrosion allowance
Coated
PSJ – Partial Jacket
FSJ – Full Jacket

BFN

BFN

2 Bag Style
P – Polyloc
S – Snap Ring

11 = (1) #1
12 = (1) #2
13 = (1) #3
14 = (1) #4

2 – Side In/Bottom Out
6 – Side In/Side Out – Offset

CS – Carbon Steel
304 – 304 Stainless
316 – 316 Stainless

150 – 150 PSI
300 – 300 PSI

1 NPT	1 FLG
1¼ NPT	1¼ FLG
1½ NPT	1½ FLG
2 NPT	2 FLG
2½ NPT	2½ FLG
3 NPT	3 FLG
	4 FLG

FSI's "comprehensive manufacturing control" philosophy insures that we will maintain our status as the industry leader in all phases of the filter business. For more information, technical consultation, or details about our custom design capability, contact your FSI representative or our headquarters in Michigan City, Indiana.

FSI®

Filter Specialists, Inc.

100 Anchor Road, P.O. Box 735 • Michigan City, IN 46361 • 1-800-348-3205 • 219/879-3307 (Indiana) • Telex: 25929 • Fax: 219/879-0744

FORM #190

MANUAL FOR THE INSTALLATION, OPERATION AND MAINTENANCE

OF

FILTER VESSELS

FILTER SPECIALISTS, INC.
MICHIGAN CITY, INDIANA
(219) 879-3307

IMPORTANT!!

Read and Understand ENTIRE Manual Before Operating This Vessel

THIS MANUAL CONTAINS IMPORTANT REVISED INFORMATION AND SUPERSEDES ALL PRIOR PUBLICATIONS.

JA 90 MR 90

NO 91

SAFETY

THIS MANUAL HAS BEEN PREPARED FOR THE SAFE INSTALLATION, OPERATION AND MAINTENANCE OF FSI PRESSURE VESSELS. WARNING LABELS HAVE BEEN RE-PRINTED IN THIS MANUAL. THE APPLICATION OF WARNING LABELS TO VESSELS IS BASED UPON VESSEL TYPE AND ADEQUATE SPACE TO AFFIX LABELS. **WARNING LABELS ARE NOT A SUBSTITUTE FOR READING AND UNDERSTANDING THIS MANUAL.**

LABEL FORMAT

A. HAZARD ALERT WORD

B. HAZARD AND CONSEQUENCE STATEMENT

C. INSTRUCTION STATEMENT

	⚠ **WARNING**
A. →	IMPROPER USE OF THIS VESSEL CAN CAUSE SERIOUS INJURY, BLINDNESS OR DEATH.
B. →	READ THE VESSEL ASME CODE PLATE, WARNING LABELS, AND THIS INSTRUCTION MANUAL FOR THE INSTALLATION, OPERATION AND MAINTENANCE OF FILTER VESSELS BEFORE INSTALLATION AND
C. →	OPERATION.

ALL LABELS MUST BE REPLACED WHEN LEGIBILITY IS LOST OR VISIBILITY IS BLOCKED. LABELS HAVE A PART NUMBER IN THE LOWER RIGHT HAND CORNER FOR RE-ORDERING.

PROTECTIVE CLOTHING

WARNING: BEFORE OPERATING THIS VESSEL, OPERATOR SHOULD WEAR PROTECTIVE CLOTHING INCLUDING PROTECTIVE GLOVES AND FACE SHIELD. IF HANDLING HOT LIQUIDS, OPERATOR SHOULD WEAR HEAT-RESISTANT CLOTHING SUCH AS NOMEX GARMENTS TO PREVENT POSSIBLE BURNING OR SCALDING. REFER TO MATERIAL SAFETY DATA SHEET (MSDS) FOR SPECIFIC INSTRUCTIONS FOR HANDLING THE LIQUID AS SUPPLIED BY THE MANUFACTURER OF THE MATERIAL.

INSTALLATION

I. MOVING VESSEL

A. MOUNT VESSEL SECURELY TO A SKID AND MOVE SKID WITH FORK LIFT.

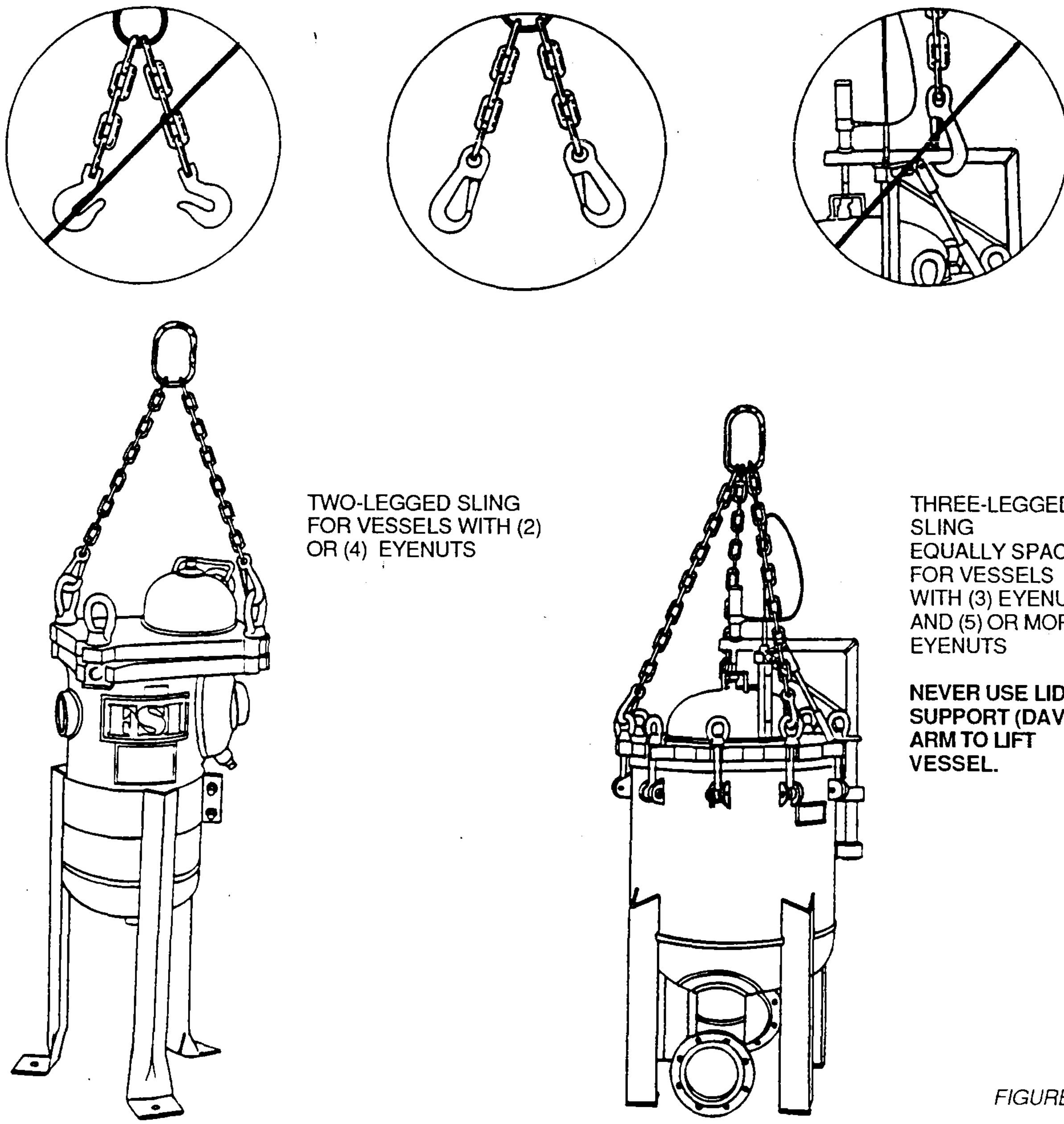
B. VESSEL CAN BE LIFTED BY MEANS OF A MULTI-LEGGED SLING CHAIN WITH A SAFETY HOOK ATTACHED TO THE END OF EACH LEG. ATTACH THE HOOK OF EACH LEG TO AN EYENUT AND SPACE LEGS AROUND VESSEL EQUALLY. *(SEE FIGURE 1 - PAGE 2)*

WARNING

NEVER USE THE LID SUPPORT ARM TO LIFT VESSEL

DAMAGE TO LIFT ASSEMBLY WILL RESULT

VESSEL MAY DROP



TWO-LEGGED SLING
FOR VESSELS WITH (2)
OR (4) EYENUTS

THREE-LEGGED
SLING
EQUALLY SPACED
FOR VESSELS
WITH (3) EYENUTS,
AND (5) OR MORE
EYENUTS

NEVER USE LID SUPPORT (DAVIT) ARM TO LIFT VESSEL.

FIGURE 1

FOR VESSEL WEIGHT, CHECK THE BILL OF LADING

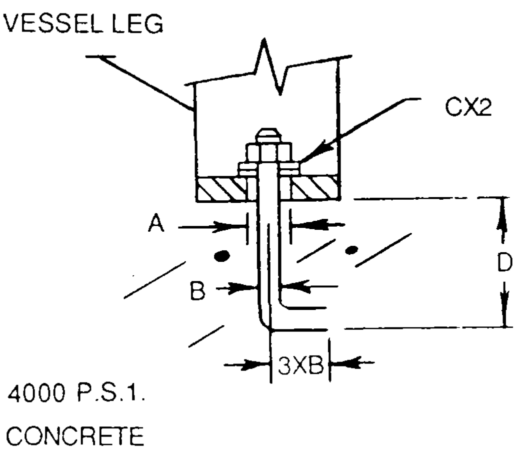
II. PLACEMENT OF MANUAL FOR THE INSTALLATION, OPERATION AND MAINTENANCE OF FILTER VESSELS

THE END USER IS TO LOCATE ONE MANUAL FOR THE INSTALLATION, OPERATION AND MAINTENANCE OF FILTER VESSELS ON EACH VESSEL AT FINAL INSTALLATION SO IT IS VISIBLE AND ACCESSIBLE TO AN OPERATOR.

III. MOUNTING

ALL VESSELS MUST BE PROPERLY BOLTED TO THE FLOOR BEFORE MOVING THE LID. THIS WILL ASSURE VESSEL STABILITY AND PREVENT TIPPING.

NEW FLOOR CONSTRUCTION



A	B	C			D	
Mounting Plt. Hole Dia.	Anchor Thd. Dia.	Amer. Stnd. Plane Washer			Embed-ment	Min. Pullout
		ID	OD	THK		
17/32 in 13.4 mm	3/8 9.5	7/16 11	1 25.4	.10 2.5	3 76	4000 lb 1814 kg
1 in 25.4 mm	1/2 12.7	9/16 14.3	1-3/8 34.9	.13 3.3	4 101	7500 lb 3402 kg

EXISTING CONCRETE FLOOR

FOR VESSELS PLACED ON EXISTING FLOORS, USE THE FOLLOWING OR AN EQUIVALENT:

RED 1 — CHEM THREADED ANCHOR ROD
RED 1 — CHEM CAPSULES

REFER TO MANUFACTURER'S LITERATURE FOR PART NUMBER AND INSTALLATION INSTRUCTIONS.

ITW RAMSET/RED HEAD
U.S. 12 & LIBERTY TRAIL
MICHIGAN CITY, IN 46360
PHONE NUMBER: 219-874-4217
TELEX NUMBER: 258488
TELEFAX NUMBER: 219-874-7035

IV. PIPING

THE PIPING MATERIAL USED SHOULD BE THE SAME AS THE BASE MATERIAL OF THE VESSEL. IT SHOULD HAVE A RATING EQUAL TO OR GREATER THAN THE PRESSURE AND TEMPERATURE RATING OF THE VESSEL.

V. RELIEF VALVE

IT IS THE RESPONSIBILITY OF THE END USER TO PROTECT SYSTEMS COMPONENTS, SUCH AS THE F.S.I. FILTER, FROM BEING OVER PRESSURIZED. THIS CAN BE ACHIEVED BY INSTALLING A SYSTEM RELIEF VALVE.

VI. PRESSURE GAUGE, TEMPERATURE GAUGE, AND VENT VALVE

F.S.I. DOES NOT SUPPLY THE VESSEL PRESSURE GAUGE, TEMPERATURE GAUGE, OR THE VENT VALVE. IT IS THE RESPONSIBILITY OF THE END USER TO OBTAIN, INSTALL AND MAINTAIN THE PROPER GAUGE, INDICATING VESSEL TEMPERATURE AND INTERNAL VESSEL PRESSURE. *(REFER TO FIGURE 2 - PAGE 6)*

VII. GASKET

⚠ **WARNING**
GASKETS CAN FAIL, CAUSING SERIOUS INJURY AND/OR BLINDNESS. GASKET MATERIAL MUST BE CHEMICALLY AND TEMPERATURE COMPATIBLE WITH FLUID BEING FILTERED.

NOTE THE OPERATING TEMPERATURE OF A GASKET MATERIAL CHANGES WITH RESPECT TO THE FLUID TEMPERATURE AND CHEMICAL CONCENTRATION.

EACH F.S.I. GASKET IS LABELED TO SHOW THE VESSEL TYPE IT WILL FIT AND THE GASKET MATERIAL.

EXAMPLE:

LABEL FORMAT

VESSEL TYPE →	FS 3500, 3000,2500 30021 FSP 4000
GASKET MAT. →	VITON

SPECIAL INSTRUCTION LABELS

GASKET INSTALLED WITH LIPS TOWARD CENTER OF VESSEL

USE ONLY FSI APPROVED GASKETS.

VIII. SYSTEM CHECK

IT IS ADVISABLE TO HYDRO-STATICALLY TEST THIS VESSEL WITH WATER TO DETERMINE IF THERE ARE ANY LEAKS IN THE SYSTEM.

SHOULD THERE BE ANY QUESTIONS, OR IF ASSISTANCE IS NEEDED IN THE INSTALLATION, OPERATION OR MAINTENANCE OF THIS VESSEL, PLEASE CONTACT THE ENGINEERING DEPARTMENT, FILTER SPECIALISTS, INC., P.O. BOX 735, MICHIGAN CITY, IN 46360. PHONE: (219) 879-3307 — FAX: (219) 879-0744

MAINTENANCE

I. MANUAL LIFTING DEVICE: *REFER TO FIGURE 2 - PAGE 6*

THIS DEVICE CONSISTS OF A THREADED STUD ITEM 16* WELDED TO THE LID AND AN INTERNALLY THREADED CRANK HANDLE IT.15.

A. KEEP THREADS CLEAN AND WELL LUBRICATED WITH A LUBRICANT ACCEPTABLE FOR THE CUSTOMER'S APPLICATION.

B. THREADS SHOULD BE INSPECTED PERIODICALLY FOR WEAR AND TEAR. SHOULD THE WEAR BECOME EXCESSIVE, PARTS SHOULD BE REPLACED BY AUTHORIZED F.S.I. PARTS.

CRANK HANDLE	—	P/N 26004 SPECIFY CARBON STEEL OR STAINLESS STEEL VESSEL
* THREAD STUD	—	P/N 20521 SPECIFY CARBON STEEL OR STAINLESS STEEL VESSEL

C. LUBRICATE THE SUPPORT AND SWIVEL BLOCKS (IT.14) OF THE DAVIT ARM WHICH SUPPORTS THE LID WHEN OPENED.

II. HYDRAULIC LIFTING DEVICE: *REFER TO FIGURE 2- PAGE 6*

F.S.I. OFFERS THREE BASIC LID LIFTING CYLINDER ASSEMBLIES. SEE *TABLE (1) ONE - PAGE 6* FOR REPLACEMENT PARTS.

A. MAINTAIN THE HYDRAULIC RESERVOIR IN THE DUMP (IT.12) WITH HYDRAULIC FLUID. REFER TO THE MANUFACTURER'S MAINTENANCE LITERATURE *(ENCLOSED - SEE PAGE 7).* THE PUMP RELIEF VALVE IS FACTORY SET TO PREVENT EXCESS PRESSURE (1800 PSI).

B. CHECK THE HYDRAULIC HOSES (IT.13) PERIODICALLY FOR TEAR, ABRASION AND KINKS. REPLACE IF NEEDED.

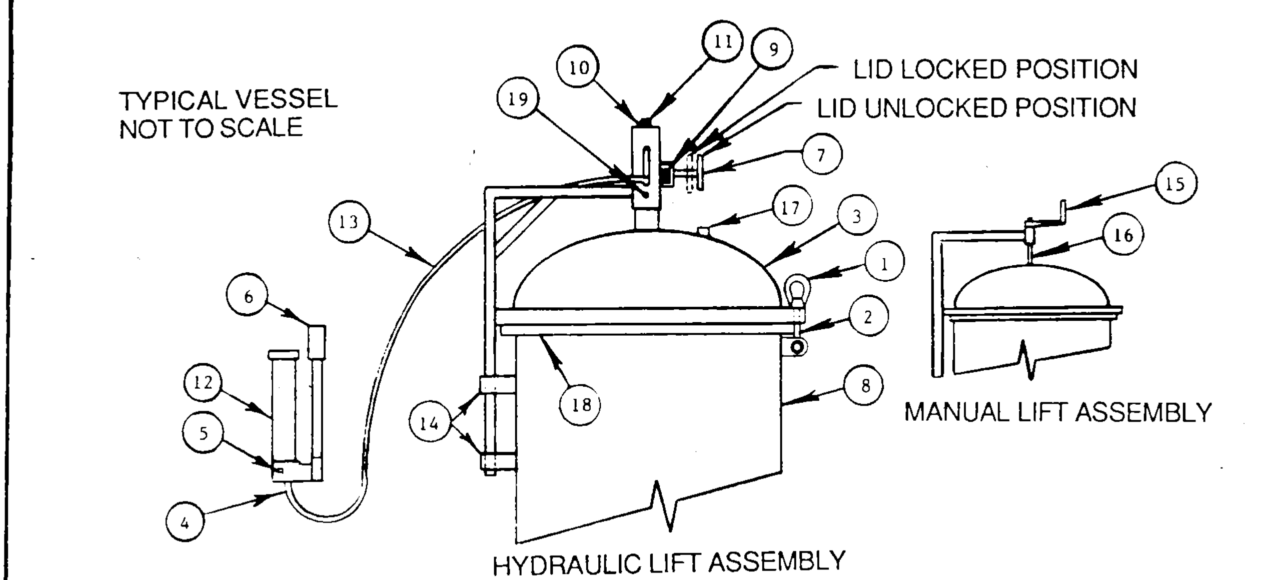
C. THERE ARE TWO (2) NUTS ATTACHED TO THE END OF THE CYLINDER ROD. THE FIRST IS A JAM NUT (GR5) (IT.10) AND THE SECOND A LOCK NUT WITH A NYLON INSERT (IT.11). IF ITEM 11 IS REMOVED, IT MUST BE REPLACED WITH A NEW ONE TO KEEP IT FROM VIBRATING LOOSE.

D. ON THE LIFT CYLINDER ASSEMBLIES, THE LID LOWERING RATE CAN BE SET BY ADJUSTING THE FLOW CONTROL VALVE MOUNTED IN THE CYLINDER END CAP. ADJUST SPEED SO THAT THE LID COMES DOWN SLOWLY. *(IT. 19, FIGURE 3 - PAGE 8)*

* THREADED STUD MUST BE WELDED BY AN AUTHORIZED A.S.M.E. CODE WELD FACILITY. THE VESSEL MUST BE REINSPECTED AFTER WELDING BY AN AUTHORIZED INSPECTOR.

REPLACEMENT PART LIST FOR LID LIFTING DEVICE						
GENERAL APPLICATION CHART FOR VESSELS RATED AT 150 PSI OR LESS AND **NO** CORROSION ALLOWANCE. PLEASE HAVE F.S.I. VERIFY THE ACTUAL LIFT CYLINDER ASSEMBLY BY MATCHING IT WITH THE VESSEL SERIAL NUMBER FOR ALL OTHER VESSELS.					GRADE #5	
MODEL NO.	**LIFT CYLINDER ASSY. PT. NO.**	**HYD. PUMP PT. NO.**	**HYD. HOSE PT. NO.**	**HYD. CYLINDER PT. NO.**	**LOCK NUT**	**LOCK NUT W/NYLON INSERT**
252-3500	19982	26220	26222	3/4 BORE X 3 STK #26010	1/4-28 #25115	1/4-28#25116
4000-5000	402184	26221	26222	1-1/8 BORE X 3 STK #26218	3/8-24 #25117	3/8-24 #25118
5500 and up	404342	26221	26222	1-3/8 BORE X 3 STK #26209	#25117	#25118

TABLE 1



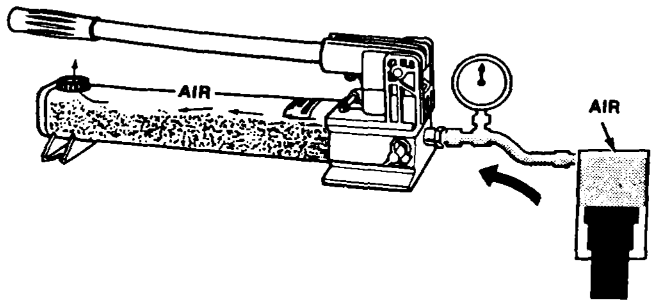
ITEM	DESCRIPTION
1	EYE NUT
2	LID RESTRNG. BOLTS
3	LID
4	PUMP HOSE END
5	PUMP RELEASE VALVE
6	PUMP HANDLE
7	SAFETY PIN
8	VESSEL BODY
9	SPRING
10	JAM NUT
11	LOCK NUT
12	HAND PUMP
13	HOSE
14	SUPPORT BLOCKS davit arm
15	HANDLE
16	STUD
17	VENT
18	COLLAR PLATE
19	FLOW CONTROL VALVE IN CYL. END CAP

FIGURE 2

OPERATION

REMOVAL OF AIR

When hoses, cylinders and other components are connected to build a system, air will be trapped in the system. To function properly, the air in the system must be removed. However, the hand pump does require air in the reservoir to prevent a vacuum. If the pump reservoir is totally filled and the vent cap is closed tight, the vacuum created will prevent oil flow out of the pump. Fill reservoirs only to level indicated on the pump end cap.



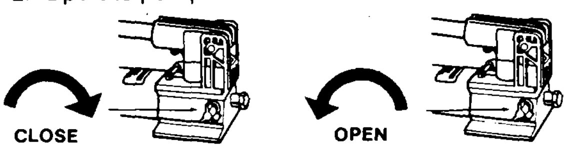
SINGLE ACTING CYLINDER SYSTEMS

1. After all system components are connected to the hand pump, check reservoir oil level. Fill to indicator mark on the end cap. Replace the fill cap and be sure it is closed (not in vent position).
2. Turn pump release valve to closed position. Operate hand pump until cylinder plunger is completely extended.
3. Invert cylinder (plunger end down). Open the pump release valve, as the plunger retracts, the air in the system will be forced into the pump reservoir and replaced by oil. Close the release valve.
4. Turn the cylinder upright. Operate the pump to cycle the cylinder plunger. If air is out of the system, the plunger will advance and retract smoothly. If the plunger is erratic, repeat steps 1 through 4.
5. Open the pump fill cap and check the oil level. Fill to the indicator mark on the end cap.

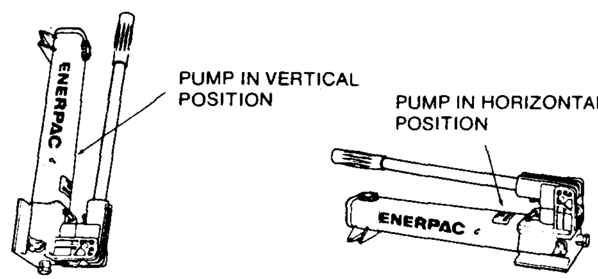
DOUBLE ACTING CYLINDERS

1. After all system components are connected to the hand pump check pump reservoir oil level. Fill to the indicator mark on the pump end cap. Replace end cap and tighten (not in vent position).
2. Place hand pump in a place where it will be higher than the hydraulic cylinder. Lay the hydraulic cylinder on its side with the couplers facing up.
3. Close the pump release valve (finger tight). Operate the pump to advance and retract the cylinder plunger three or four times.
4. Open pump release valve to retract the cylinder plunger. Check pump oil level. Add oil as necessary to restore correct level in the reservoir.

1. To advance cylinder plunger, turn pump release valve clockwise as illustrated and close **finger-tight.** CAUTION: To avoid release valve damage, do not use tools to tighten valve.
2. Operate pump handle.

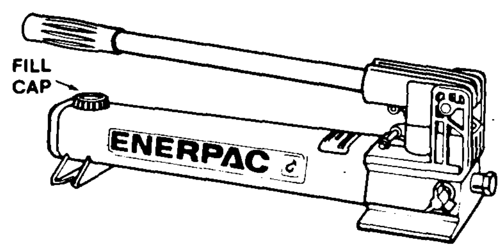


3. To retract cylinder plunger, turn release valve counterclockwise as illustrated.
4. Pump can be operated from horizontal or vertical (as long as hose end is down.)



MAINTENANCE

To check oil level in pump, open pump release valve to allow oil in cylinder (if connected) to return to pump. Remove fill cap. Add ENERPAC hydraulic oil until level with mark on rear cap. **DO NOT** overfill. To function properly all hand pumps require air int he reservoir. If oil level is too high the pump will not operate. If hydraulic system is used under extremely dirty conditions, frequently drain pump completely. Refill with clean ENERPAC hydraulic oil. Install fill cap and close it.



REPLACING COUPLER

ASSEMBLING TO HOSE (FIGURE #1)

Clamp the hexagon nut of the hose fitting in a vise as illustrated. Remove the old coupler or rigid adaptor. Install new coupler clockwise on to hose fitting to a firm fit. Use high quality thread sealer on threads (one wrap only).
A kit has been prepared for the purpose of replacing a worn out seal and may be obtained at your nearest authorized technical service center.

ASSEMBLING SPEE-D-COUPLERS TO CYLINDER (FIGURE #2)

Use wrench to unscrew old coupler half from cylinder. Thread new coupler to cylinder and tighten firmly. Use a high quality thread sealant on coupler thread (one wrap only).

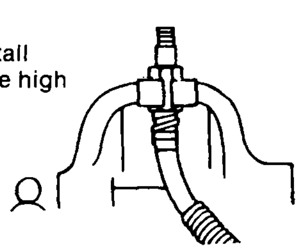


FIGURE #1

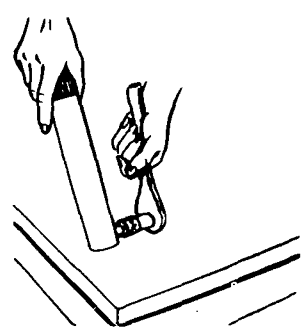


FIGURE #2

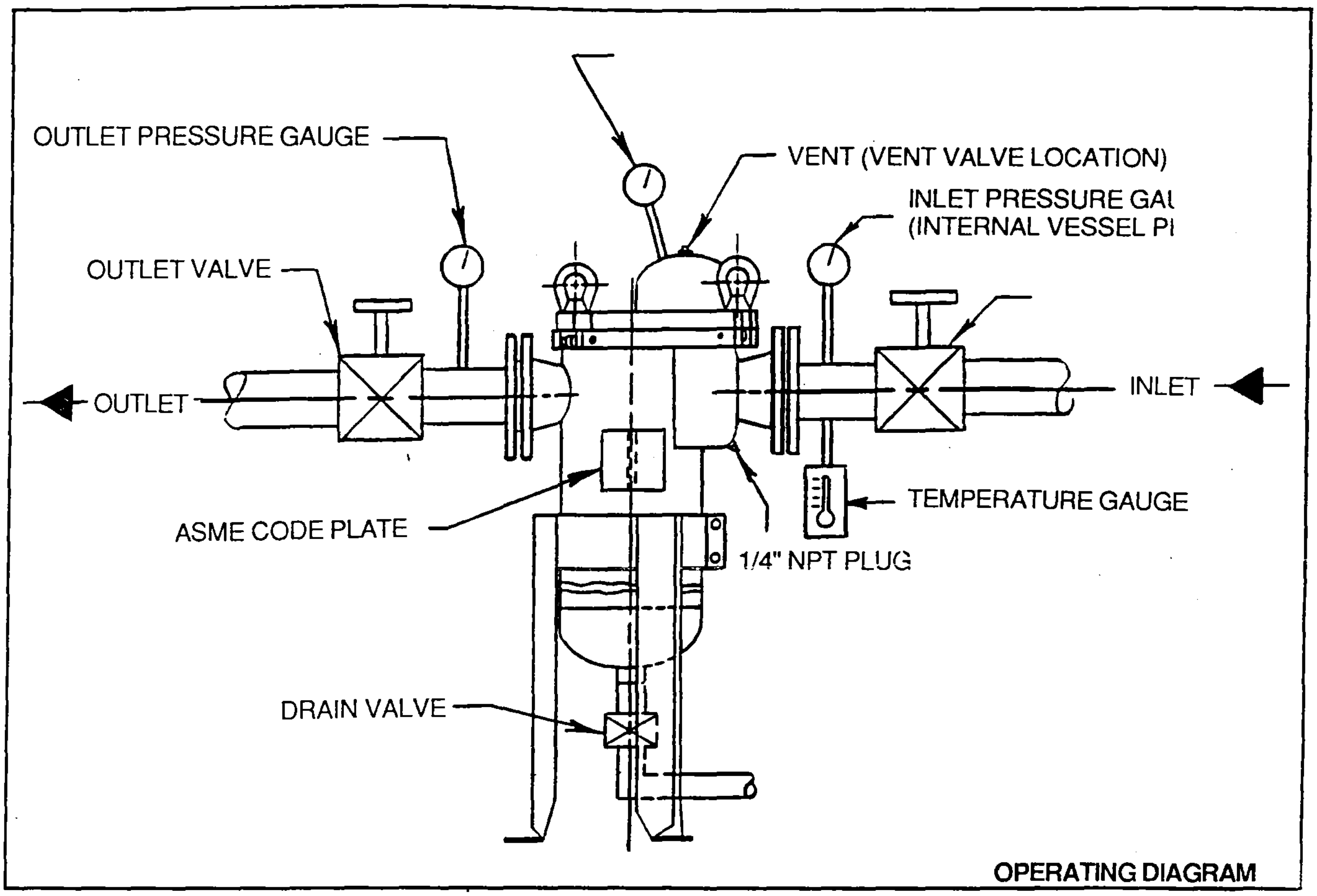


FIGURE 3

LIDS WITH NO LIFT MECHANISM — LID NUTS SHOULD BE UNSCREWED FAR ENOUGH TO ALLOW THE LID TO REST ON THE GASKET FREELY AND PARALLEL TO THE VESSEL COLLAR PLATE.

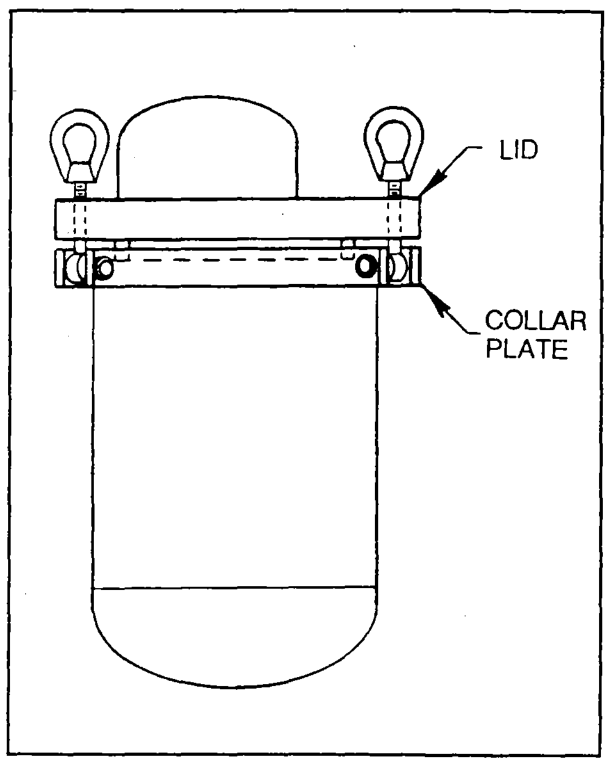


FIGURE 4

OPERATION

⚠ WARNING
HOT AND/OR CHEMICALLY ACTIVE LIQUIDS CAN CAUSE SERIOUS INJURY AND BLINDNESS.

BEFORE OPERATING THIS VESSEL, OPERATOR SHOULD WEAR PROTECTIVE CLOTHING, INCLUDING PROTECTIVE GLOVES AND FACE SHIELD. IF HANDLING HOT LIQUIDS, OPERATORS SHOULD WEAR HEAT RESISTANT CLOTHING, SUCH AS NOMEX GARMENTS, TO PREVENT POSSIBLE BURNS.

REFER TO THE MATERIAL SAFETY DATA SHEET (MSDS) FOR SPECIFIC INFORMATION ON MATERIAL. THE MSDS IS SUPPLIED BY THE MANUFACTURER OF THE MATERIAL.

⚠ WARNING
DO NOT EXCEED THE OPERATING LIMITS OF THIS VESSEL AND GASKET. SERIOUS INJURY OR DEATH CAN RESULT IF LIMITS ARE EXCEEDED.

FOR MAXIMUM PRESSURE, CHECK A.S.M.E. CODE PLATE OF VESSEL.

FOR MAXIMUM TEMPERATURE OF VESSEL, CHECK A.S.M.E. CODE PLATE.

FOR MAXIMUM OPERATING TEMPERATURE OF GASKET, CALL F.S.I., (219) 879-3307. THE MAXIMUM GASKET OPERATING TEMPERATURE CAN CHANGE WITH CHANGES IN FLUID, CHEMICAL COMPOSITION, TEMPERATURE, AND PRESSURE.

NOTE: DO NOT EXCEED THE LESSER OF THE TWO MAXIMUM TEMPERATURES.

I. INITIAL CLOSING OF VESSEL LID
VESSEL MUST BE ISOLATED FROM SYSTEM — PUMP TURNED OFF AND LOCKED OUT; INLET AND OUTLET VALVES CLOSED. *REFER TO FIGURE 3- PAGE 8.*

A. INSERT BASKET INTO SEAT. THE BASKET RIM FLANGE MUST COVER ENTIRE OPENING. IF NOT, THE BASKET MAY COCK AND BE FORCED THROUGH THE OPENING UNDER PRESSURE. *REFER TO FIGURE 5 - PAGE 12.*

B. INSERT NEW FILTER ELEMENTS, MAKING SURE THAT ALL BAGS OR CARTRIDGES ARE PROPERLY SEATED. SNAP RING BAGS MUST HAVE THE SALVAGE ON THE INSIDE OF THE BAG TO PREVENT BYPASS. *REFER TO FIGURE 5 - PAGE 12.*

C. INSPECT GASKET GROOVE AND GASKET. *REFER TO FIGURE 6 - PAGE 13.* IF GASKET IS NICKED OR WORN, REPLACE ONLY WITH F.S.I. REPLACEMENT PARTS. FOR ORDERING REPLACEMENTS, REFER TO VESSEL MODEL NUMBER AND SERIAL NUMBER.

D. INSERT GASKET, MAKING SURE GASKET IS NOT TWISTED, AND IF A LIP TYPE GASKET IS USED, THE LIPS ARE POINTING INWARD AS SHOWN IN *FIGURE 6 - PAGE 13.* IF GASKET WANTS TO ROLL OUT OF GROOVE, STRETCH GASKET SLIGHTLY BY HAND, INSPECT GASKET SEAM, AND REFIT INTO GROOVE.

E. POSITION LID FOR CLOSING.

1. LIDS WITH NO LIFT MECHANISM — LID NUTS MUST BE UNSCREWED FAR ENOUGH TO ALLOW THE LID TO REST ON THE GASKET FREELY AND PARALLEL TO THE VESSEL COLLAR PLATE. *REFER TO FIGURE 4 - PAGE 8.*

2. LIDS WITH A CRANK. *REFER TO FIGURE 3 - PAGE 8.*

   a. ROTATE LID OVER VESSEL SO THE EYE NUT AND BOLT BRACKET ARE IN LINE.

   b. TURN CRANK TO LOWER LID.

   c. REALIGN BRACKETS, IF NECESSARY, BEFORE LID SETS DOWN ON VESSEL BODY.

3. LIDS WITH HYDRAULIC LIFTS. *REFER TO FIGURE 2 - PAGE 6.*

   a. REFER TO STEPS E2a, E2b, and E2c.

   b. HOLD HAND PUMP IN VERTICAL POSITION WITH HOSE END DOWN AND RAISE LID SLIGHTLY.

   c. WITH ONE HAND, PULL SAFETY PIN OUT TO DISENGAGE IT. HOLD IN THIS POSITION.

   d. WITH OTHER HAND, CRACK OPEN THE PUMP RELEASE VALVE.

   e. LOWER LID UNTIL IT ALMOST TOUCHES GASKET, RELEASE SAFETY PIN, ALIGN EYEBOLT AND EYENUT BRACKETS, AND CONTINUE TO LOWER LID UNTIL IT RESTS FREELY ON THE GASKET.

⚠ WARNING
A FALLING LID CAN CAUSE SERIOUS INJURY AND LOSS OF LIMB. NEVER PLACE HANDS, FINGERS, OR LIMBS BETWEEN LID AND VESSEL.

F. ENGAGE ALL BOLTS. HAND TIGHTEN NUTS. *REFER TO FIGURE 7 - PAGE 13.*

G. MODERATELY TORQUE NUTS AT 180° TO EACH OTHER, ROTATING AROUND THE VESSEL UNTIL TIGHT. *REFER TO FIGURE 7 - PAGE 13.*

H. CLOSE VENT VALVE. *REFER TO FIGURE 3 - PAGE 8.*

I. TURN PUMP ON.

J. OPEN INLET VALVE SLOWLY AND OBSERVE FOR LEAKS. SHOULD ANY LEAKS APPEAR, CLOSE VALVE IMMEDIATELY AND CONTINUE WITH PART II. *REFER TO FIGURE 2 - PAGE 6.*

K. IF NECESSARY, FILL VESSEL WITH PRODUCT BY EVACUATING THE AIR VIA THE VENT VALVE.

L. OPEN OUTLET VALVE. *REFER TO FIGURE 3 - PAGE 8.*

II. <u>OPENING AND CLOSING OF THE VESSEL LID</u>

ADHERE TO THE FOLLOWING SEQUENCE. *REFER TO FIGURE 2 - PAGE 6.*

⚠ DANGER
DO NOT OPEN A VESSEL UNDER PRESSURE. ESCAPING FLUID UNDER PRESSURE CAN CAUSE SERIOUS INJURY AND BLINDNESS.

A. BEFORE OPENING VESSEL

1. TURN OFF PUMP AND LOCK IT OUT
2. CLOSE INLET AND OUTLET VALVE

B. OPEN VENT VALVE. MAKE SURE THAT THE VALVE OUTLET IS SO PIPED THAT ESCAPING FLUIDS ARE SO DIRECTED TO PREVENT PERSONAL INJURY OF THE OPERATOR AND SURROUNDING AREA.

C. CHECK PRESSURE GAUGE TO MAKE SURE THAT THE ISOLATED VESSELS' INTERNAL PRESSURE IS ZERO PSI GAUGE. *REFER TO FIGURE 3 - PAGE 8.*

D. DRAIN FLUID FROM VESSEL BY GRAVITY FLOW THROUGH DRAIN VALVE. CLOSE DRAIN VALVE. EVACUATION CAN BE ASSISTED WITH PRESSURIZATION. *REFER TO "BLOW DOWN PROCEDURES", PAGE 14.*

E. LOOSEN LID NUTS AND SWING NUT AND BOLTS FREE OF LID.

F. LIFT LID.

LIDS WITH HYDRAULIC LIFTS:
HOLD HAND PUMP VERTICALLY WITH HOSE END DOWN. CLOSE PUMP RELEASE VALVE AND PUMP UNTIL LID LIFTS HIGH ENOUGH TO ENGAGE SPRING LOADED SAFETY PIN.

⚠ WARNING
A FALLING LID CAN CAUSE LOSS OF LIMB. SAFETY PIN MUST BE ENGAGED WHEN LID IS OPEN.

G. ROTATE LID OFF OF VESSEL.

H. REMOVE FILTER BAG OR CARTRIDGES WITH CAUTION.

I. INSPECT BASKET FOR ROUNDNESS AND FLANGE CONDITION.

J. VERIFY THAT BASKET AND BAG BEARING SURFACES ARE CLEAN AND FREE OF NICKS.

K. INSERT NEW FILTER ELEMENTS, MAKING SURE THAT ALL BAGS OR CARTRIDGES ARE PROPERLY SEATED. SNAP RING BAGS MUST HAVE SALVAGE ON INSIDE OF BAG. *REFER TO FIGURE 5 - PAGE 12.*

L. REMOVE GASKET, CLEAN GASKET GROOVE. IF GASKET IS WORN OR NICKED, REPLACE ONLY WITH F.S.I. REPLACEMENT PARTS. FOR CORRECT REPLACEMENTS, REFER TO THE VESSEL MODEL NUMBER AND SERIAL NUMBER. USE ONLY F.S.I. AUTHORIZED GASKETS.

M. ROTATE LID OVER VESSEL AND ALIGN BOLT AND NUT BRACKETS.

N. CLOSE LID. SAME AS E1, E2 AND E3, - *PAGE 10.*

O. SAME AS I. F.

P. SAME AS I. G.

Q. SAME AS I. H.

R. SAME AS I.L.

S. SAME AS I. J.

T. SAME AS I. K.

U. SAME AS I.L.

IF A VESSEL STILL LEAKS, DEPRESSURIZE VESSEL AND RETORQUE BOLTS ACCORDING TO STEP I. G. - *PAGE 10.* IF VESSEL LEAKAGE CONTINUES, CALL F.S.I.

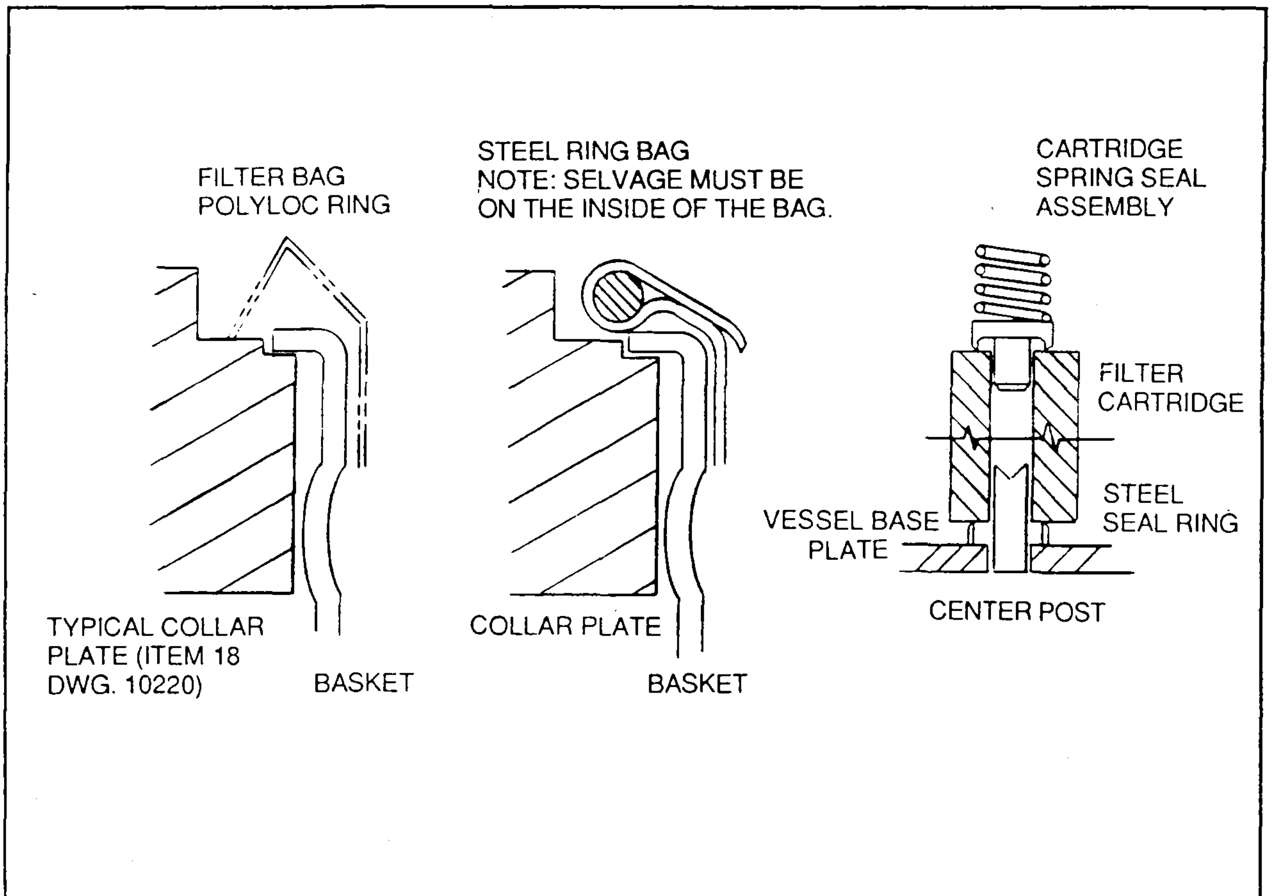


FIGURE 5

GASKET INSTALLATION

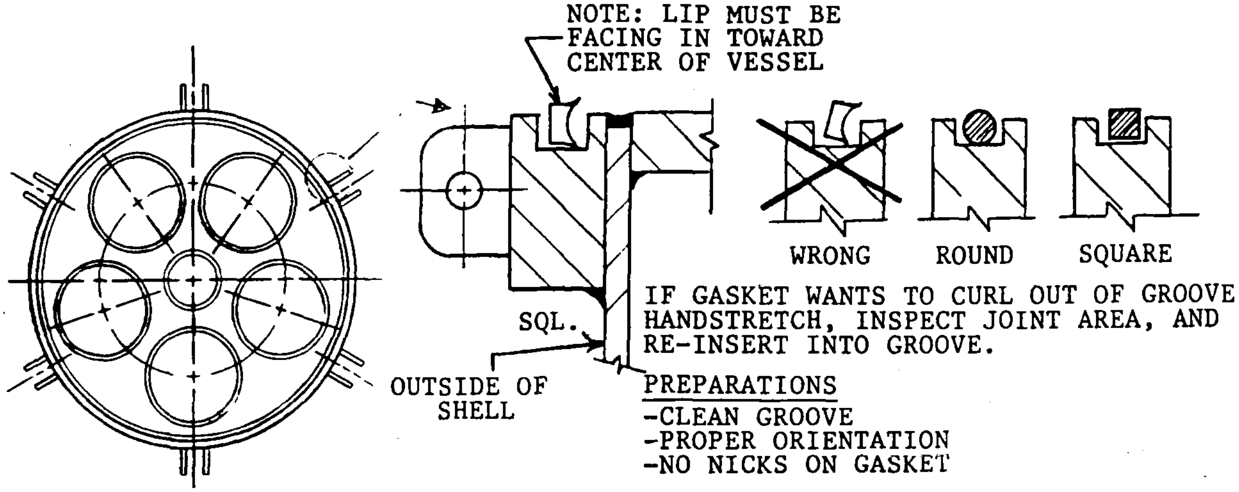
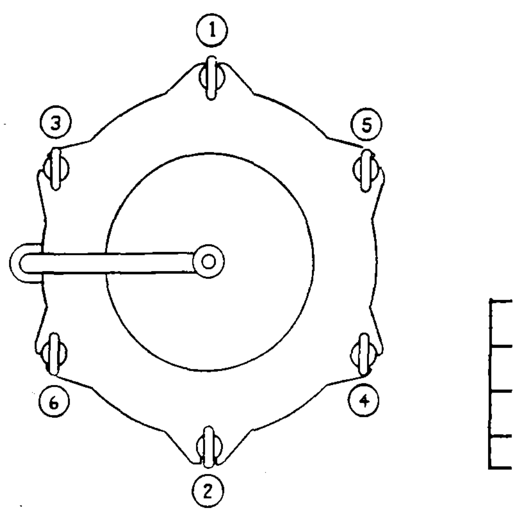


FIGURE 6

BOLT TIGHTENING SEQUENCE



NOTE: EXCESSIVE TORQUE SHOULD NOT BE NECESSARY WHEN USING FSI SELF ENERGIZING GASKETS.

FIGURE 7

STANDARD FSI VESSELS ARE DESIGNED TO USE GASKETS MADE OF SELF ENERGIZING MATERIAL, SUCH AS BUNA, EPR OR VITON. THE TORQUE REQUIREMENTS TO SEAL A VESSEL WITH SUCH GASKETS IS MINIMAL. IT IS, THEREFORE, NOT NECESSARY TO USE EXTENSIONS OR CHEATER BARS WHEN TORQUING EYENUTS. FSI DOES NOT RECOMMEND THE USE OF GASKETS MADE OF NON-ENERGIZING MATERIAL OR ROPE TYPE GASKETS. THEY MAY REQUIRE EXCESSIVE TIGHTENING TORQUE. DUE TO THE MANY VARIABLES THAT INFLUENCE TORQUE, EXACT VALUES ARE NOT GIVEN HEREIN. FOR GENERAL TORQUE VALUES APPLICABLE TO YOUR PARTICULAR VESSEL, CALL FILTER SPECIALISTS AT 1-800-348-3205.

BLOW DOWN PROCEDURE

TO AID FILTER ELEMENT CHANGES, THE LIQUID IN THE VESSEL CAN BE EVACUATED PRIOR TO THE CHANGE.

WARNING: THE GAS USED FOR BLOW DOWN MUST BE STABLE IN THE ENVIRONMENT OF THE FLUID BEING EVACUATED.

1. CLOSE INLET VALVE. *REFER TO FIGURE 3 - PAGE 8.*
2. CLOSE OUTLET VALVE.
3. OPEN VENT VALVE.
4. CHECK GAUGE — INTERNAL PRESSURE MUST BE ZERO.
5. OPEN DRAIN VALVE.
6. CLOSE VENT.
7. CONNECT GAS TO VESSEL VIA VENT VALVE. USE ONLY IF GRAVITY EVACUATION DOES NOT YIELD DESIRED RESULTS.
8. OPEN VENT VALVE SLOWLY.
9. CLOSE VENT VALVE AFTER METERING OUT FLUID.
10. DISCONNECT GAS.
11. CLOSE DRAIN VALVE.
12. MAKE SURE INTERNAL PRESSURE IS ZERO AND CONTINUE WITH OPENING INSTRUCTIONS.

FILTER IN OPERATION

ONCE THE FILTER IS OPERATIONAL AND IN USE, THE DIFFERENTIAL PRESSURE SHOULD BE CHECKED REGULARLY. IT IS SUGGESTED THAT WHEN THE DIFFERENTIAL PRESSURE ACROSS THE FILTER ELEMENTS REACHES A PREDETERMINED AMOUNT, THE ELEMENTS BE CHANGED. IF THE DIFFERENTIAL PRESSURE SUDDENLY DROPS, STOP FILTRATION IMMEDIATELY AND CHECK BAGS FOR PROPER SEAL OR RUPTURE.

WARNING

- VESSEL MAY TIP IF NOT PROPERLY BOLTED TO FLOOR.
- A TIPPING VESSEL CAN CAUSE SERIOUS INJURY.
- PROPERLY BOLT VESSEL TO FLOOR BEFORE ROTATING LID.
- REFER TO MANUAL FOR THE INSTALLATION, OPERATION AND MAINTENANCE OF FILTER VESSELS.

1289 PT. NO. 35002

WARNING

- PRESSURE GAGE AND VENT VALVE MUST BE INSTALLED IN ACCESS HOLE.
- FAILURE TO INSTALL PRESSURE GAGE AND VENT VALVE CAN RESULT IN SERIOUS INJURY WHEN OPENING THE LID.
- DIRECT VENT VALVE EXHAUST TO A SAFE PLACE.

1289 PT. NO. 35001

⚠ WARNING

- GASKET SEAL MAY LEAK OR SQUIRT FLUID UNDER PRESSURE IF THE LID OPENING AND CLOSING INSTRUCTIONS ARE NOT FOLLOWED.
- SQUIRTING FLUID CAN CAUSE SERIOUS INJURY OR BLINDNESS.
- READ THE MANUAL FOR INSTALLATION, OPERATION, AND MAINTENANCE OF FILTER VESSELS.
- WEAR PROTECTIVE CLOTHING.
- WEAR FACE SHIELD.
- BEFORE OPENING, TURN PUMP OFF AND LOCK IT OUT.
- CLOSE INLET AND OUTLET VALVE.
- OPEN VENT SLOWLY-DIRECT EXHAUST TO SAFE PLACE.
- INTERNAL PRESSURE SHOULD BE ZERO(0) PSI GAGE.
- DRAIN FLUID VIA DRAIN VALVE.
- CLOSE DRAIN VALVE.
- UNBOLT LID LUGS.
- LIFT LID.
- ENGAGE LID SAFETY PIN (IF APPLICABLE).
- ROTATE LID, UNCOVERING VESSEL.
- CHANGE FILTER ELEMENT.
- REMOVE GASKET, CLEAN GASKET GROOVE AND GASKET.
- INSPECT GASKET GROOVE AND LID SEALING AREA FOR DAMAGE.
- REPLACE DAMAGED PARTS WITH F.S.I. REPLACEMENT PARTS ONLY.
- REPOSITION LID, DISENGAGE SAFETY PIN AND LOWER LID ONTO VESSEL SLOWLY.
- REPLACE WASHERS UNDER NUTS IF NECESSARY.
- ENGAGE ALL BOLTS, HAND TIGHTEN NUTS.
- NUT AND BOLT THREADS TO BE FREE OF RUST AND FOREIGN MATTER.
- MODERATELY TORQUE NUTS AT 180° TO EACH OTHER ROTATING AROUND VESSEL.
- CLOSE VENT VALVE.
- ACTIVATE PUMP.
- OPEN INLET VALVE SLOWLY. OBSERVE FOR LEAKS. IF LEAK APPEARS, CLOSE VALVE AND START OVER.
- IF THERE ARE NO LEAKS, OPEN OUTLET VALVE SLOWLY.

1289 PT. NO. 35004

⚠ WARNING

- VESSEL AND OR GASKET CAN FAIL IF OPERATING LIMITS ARE EXCEEDED.
- A FAILURE CAN CAUSE SERIOUS INJURY, BLINDNESS, OR DEATH.
- DO NOT EXCEED MAXIMUM OPERATING PRESSURE PER VESSEL CODE PLATE.
- CHECK TEMPERATURE RANGE ON VESSEL CODE PLATE.
- CHECK TEMPERATURE RANGE OF GASKET MATERIAL WITH RESPECT TOP FLUID BEING FILTERED.
- DO NOT EXCEED THE LESSER OF THE TWO OPERATING TEMPERATURES.
- SECURE LID BY TIGHTENING LID EYENUTS.
- READ THE MANUAL FOR THE INSTALLATION, OPERATION, AND MAINTENANCE OF FILTER VESSELS.

1289 PT. NO. 35000

⚠ WARNING

- RAISED LID MAY FALL IN THE EVENT OF A HYDRAULIC OR MECHANICAL FAILURE.
- A FALLING LID CAN SERIOUSLY INJURE OR CAUSE LOSS OF LIMB.
- REFER TO F.S.I. OPERATING & MAINTENANCE INSTRUCTIONS.
- READ AND UNDERSTAND THE FOLLOWING INSTRUCTIONS:
  - NO BODILY PARTS UNDER THE LID AT ANY TIME.
  - WEAR EYE PROTECTION IN CASE OF HYDRAULIC COMPONENT RUPTURE.
  - ENGAGE LID SAFETY LATCH WHERE APPLICABLE.

1289 PT. NO. 35003

⚠ WARNING

- IF IMPROPERLY USED THIS VESSEL CAN CAUSE SERIOUS INJURY, BLINDNESS OR DEATH.
- READ ALL WARNING LABELS AND MANUAL FOR INSTALLATION, OPERATING/MAINTENANCE OF FILTER VESSEL BEFORE USE.
- FOR ADDITIONAL MANUALS CALL F.S.I. 1-800-348-3205

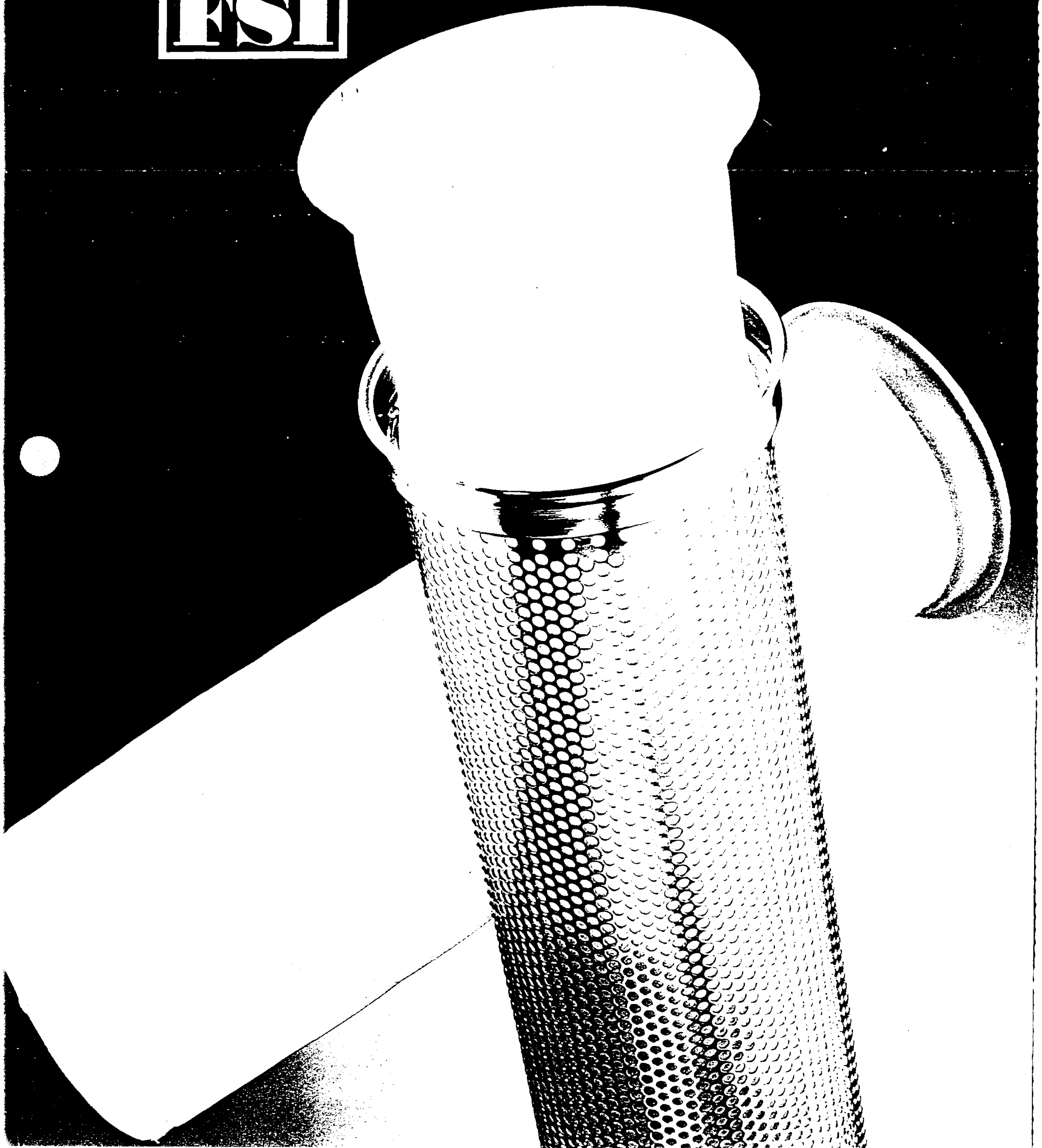
PT. NO. 35005

NMO5 NMO10 NMO25 NMO35 NMO45
NMO55 NMO75 NMO100 NMO150 NMO200

POLYWELD® MONOFILAMENT MESH FILTER BAGS

MONOFILAMENT MESH OFFERS HIGH FLOW RATES, LONG SERVICE LIFE, AND CONSISTENT PERFORMANCE.

FSI



NMO5	NMO55
NMO10	NMO75
NMO25	NMO100
NMO35	NMO150
NMO45	NMO200

POLYWELD® MONOFILAMENT MESH FILTER BAGS

FEATURES	BENEFITS
Welded seam construction	No needle holes – fluid will not bypass filter media
Uniform mesh openings	Precise filtration
Scoured finish	High purity – oil and lubricant free
Large open area	High through-put
Smooth fiber surface	Excellent cake release Superior resistance to blinding
Compacts to small volume	Reduces disposal cost
Heat set fabric	Dimensional stability for consistent performance Mesh filaments will not shift or deform under pressure
Monofilament yarn	Abrasion resistant Broad range of chemical resistance High tensile strength Unaffected by metal fatigue or corrosion No loose fibers

STANDARD BAG SIZE	COLLAR	OPTIMUM FLOW RATES
#3 – 4" x 9"	Polyloc	20 GPM
#4 – 4" x 15"	Polyloc	35 GPM

Differential pressure: 35 PSIG maximum recommended
10 – 15 PSIG optimum change-out
1 – 3 PSIG initial

Operating temperatures: Maximum continuous – 200°F

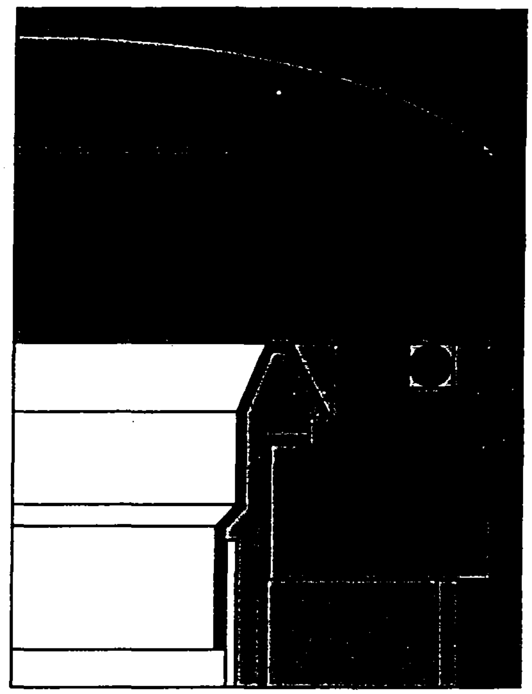
MICRON RATINGS

5	55
10	75
25,	100
35	150
45	200

MATERIAL

Nylon/Polypropylene

POLYLOC® POSITIVE BAG HOLD-DOWN



Hermetic seal of filter bag within housing to prevent liquid bypass

FSI® 100 Anchor Road
P.O. Box 735
Michigan City, IN 46361
219/879-3307
219/879-0744 Fax
Filter Specialists, Inc. 800-348-3205

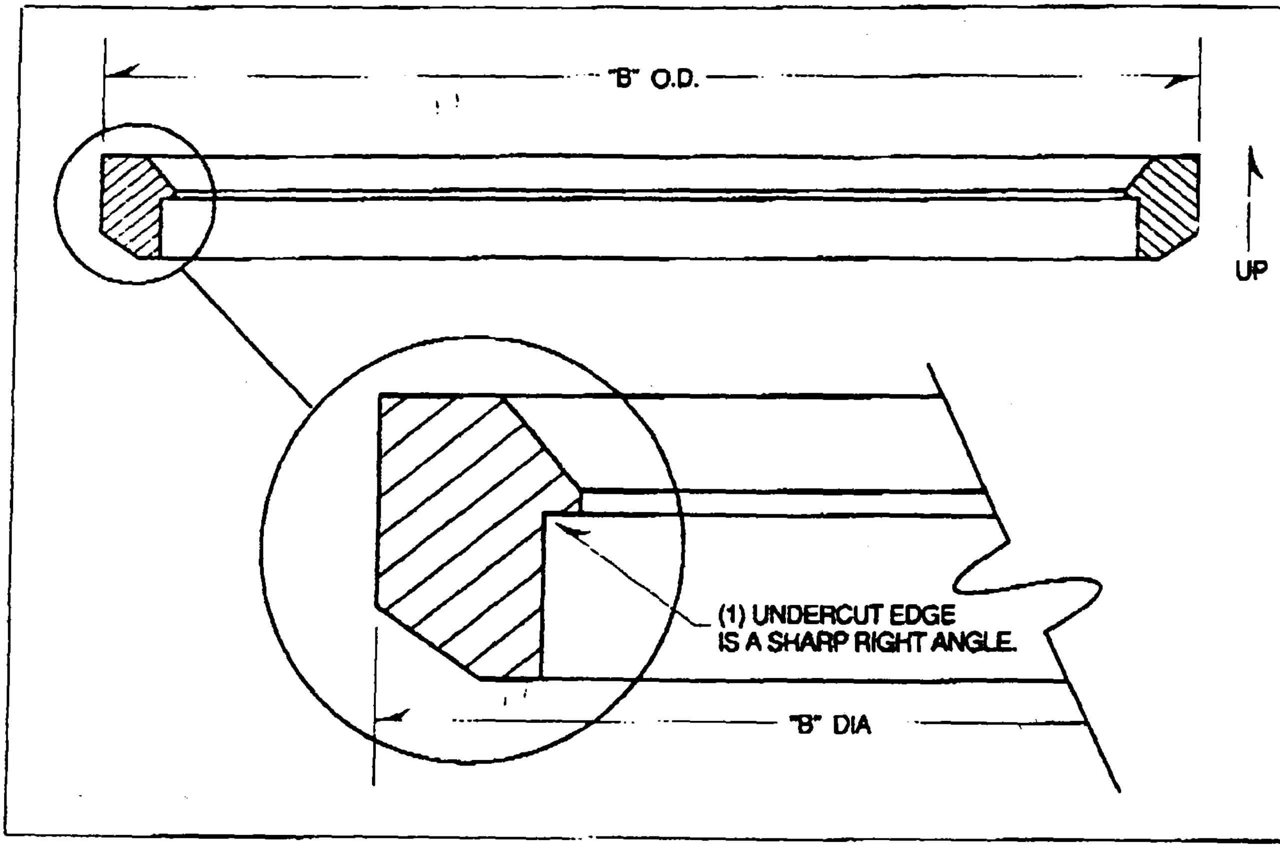
NMB-004-295

MANUFACTURED IN THE USA

PRINTED IN USA

POLYLOC® INSERT RING

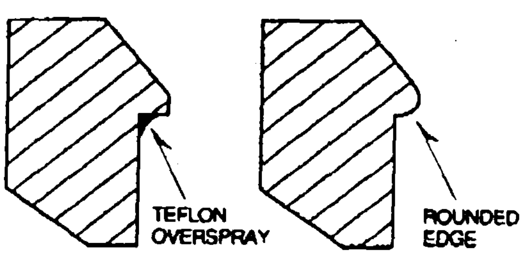
FOR SNAP-FIT BAG†



ITEM	INSERT RING PART NO.	DIAMETER OF BORE IN HOUSING COLLAR PLATE	TEFLON COATED INSERT RING "B"*
1	PS26345C	7.375/7.370	7.379
2	PS26343C	7.380/7.375	7.387
3	PS26346C	7.385/7.380	7.396

* Ring is Teflon coated on the outside surface only. Coating is applied .002/.003 thick per side. Ring is 316SS. Teflon is FDA grade.

† This bulletin is an abbreviated version of drawing FSI #14018. It is sufficient for the purpose of retrofitting filter housings with Polyloc insert rings in the field. Should you have any questions or require greater detail, please contact the FSI Engineering Department.



(1) Make a visual inspection to ensure that this undercut edge is machined properly and does not have a shallow rounded lip or build-up of Teflon overspray. Return to FSI if either of these conditions exist.

FSI

Filter Specialists, Inc.
100 Anchor Road, P.O. Box 735
Michigan City, Indiana 46360
219-879-3307 1-800-348-3205
Telex 25929

8392SNP

Ordering Information:

To order, use the abbreviations from the charts shown on this page. The charts are color coded for your convenience.

Example:

[illegible]	2	*3 [illegible]	[illegible]	[illegible]	[illegible]
PONG	10	P	2	S	R
PENG	50	PEM	1	P	AUTO

These codes describe the following bags:

1. Polypropylene Non-inserted Glazed Felt – 10 Micron – Plain – #2 Size – Snap Collar Design – Reverse Collar Construction.
2. Polyester Non-inserted Glazed Felt – 50 Micron – Polyester Multifilament Cover – #1 Size – Polyloc Collar Design – Inside Seams.

*Customer to specify micron rating if cover is used.

Filter Fabric Properties

Physical – Chemical – Temperature

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.55	44-109	Fair	Poor	Poor	Excellent	Excellent	Good	200°-240°
[illegible]	1.38	64-124	Very Good	Very Good	Good	Good	Poor	Good	275°-325°
[illegible]	2.56	200-215	Poor	Excellent	Good	Fair	Poor	Excellent	500°-600°
[illegible]	1.14	58-128	Excellent	Fair	Poor	Excellent	Excellent	Good	275°-300°
[illegible]	1.14	58-128	Very Good	Fair	Poor	Excellent	Excellent	Good	400°-450°
[illegible]	0.91	50-85	Very Good	Excellent	Excellent	Excellent	Excellent	Fair	200°-220°
[illegible]	1.69	15-44	Good	Excellent	Excellent	Excellent	Excellent	Poor	160°-185°
[illegible]	2.30	47	Poor	Excellent	Excellent	Excellent	Excellent	Very Good	450°-500°

THIS GUIDE CONTAINS GENERAL INFORMATION. ACTUAL USE OR SOAK TESTS SHOULD BE PERFORMED WHEREVER POSSIBLE.

Filter Bags

[illegible]	2 Micron Rating
PECG-polyester/cotton	1, 3
PEIF-polyester inserted	1, 3, 5, 10, 15, 25, 50, 75, 100, 200
PENF-polyester non-inserted	5, 10, 15, 25, 50, 75, 100
PEIG-polyester inserted glazed	1, 3, 5, 10, 15, 25, 50, 75, 100, 200
PENG-polyester non-inserted glazed	5, 10, 15, 25, 50, 75, 100
V-rayon-viscose felt	3, 5, 10, 15, 25
TFE-teflon felt	10, 25, 50
N-nylon felt	5, 10, 25, 50, 100
POIF-polypropylene inserted	1, 3, 5, 10, 25, 50, 100
POIG-polypropylene inserted glazed	1, 3, 5, 10, 25, 50, 100
PONG-polypropylene non-inserted glazed	5, 10, 25, 50, 100
POMF-polypropylene micro-fiber	2A, 10A, 25A, 0A
HT-nylon nomex felt	5, 10, 25, 50, 100
PEM-polyester multifilament mesh	75, 100, 125, 150, 200, 250, 400, 600, 800
PEMO-polyester monofilament mesh (special order)	5, 10, 25, 50, 75, 100, 150, 200, 250, 400, 600, 800
NM-nylon multifilament mesh	100, 150, 800
NMO-nylon monofilament mesh	5, 10, 25, 35, 50, 65, 75, 90, 100, 125, 150, 175, 200, 250, 300, 400, 600, 800
PMO-polypropylene monofilament mesh	250, 300, 400, 600, 800
S-saran monofilament mesh	300, 600, 800

3 Bag Cover	4 Bag Size Number
P – plain (no cover)	1 – #1 size bag
PEM – polyester multifilament cover	2 – #2 size bag
G – fiber free finish	3 – #3 size bag
NMO – nylon monofilament cover	4 – #4 size bag
NM – nylon multifilament cover	5 – #5 size bag
Cerex – spun bonded nylon	6 – #6 size bag
M – muslin cover	7 – #7 size bag
	8 – #8 size bag
	9 – #9 size bag

5 Bag Design	6 Suffix
P – Polyloc™	SS – 316 ss ring
S – metal retaining ring-snap collar design	PVC – PVC coated ring
PC-1 – fits #1 cuno housing	R – reverse collar
PC-2 – fits #2 cuno housing	TN – triple needle seam
CO – fits Commercial filter housing	A – adapter head
RP – fits Ronningen-Petter housing	AUTO – inside seams
RP – P – Plastic ring for above	CH – cotton handle
	L – loops

Unlike other bag manufacturers, we make all of our felts in-house. This insures better quality control of your finished product. FSI's "comprehensive manufacturing control" philosophy insures that we will maintain our status as the industry leader in all phases of the filter business. For more information, technical consultation, or details about our custom design capability, contact your FSI representative or our headquarters in Michigan City, Indiana.

FSI®

Filter Specialists, Inc.
100 Anchor Road, P.O. Box 735 • Michigan City, IN 46361
1-800-348-3205 • 219/879-3307 (Indiana) • Telex: 25929 • Fax: 219/879-0744

ATTACHMENT 7

GAUGE CHART FOR PRODUCT TANK (T-4)

GAUGE CHART FOR CYLINDRICAL HORIZONTAL TANKS

150 GALLON 30"x 48"		287 GALLON 36" x 65"		560 GALLON 42" x 93½"		1012 GALLON 45½" x 144"	
INCHES	GALLONS	INCHES	GALLONS	INCHES	GALLONS	INCHES	GALLONS
1	1	1	2	1	3.4	1	5
2	4	2	6	2	9.7	2	15
3	7	3	11	3	17.7	3	28
4	12	4	17	4	27.2	4	42
5	16	5	24	5	37.7	5	59
6	21	6	31	6	49.2	6	77
7	26	7	39	7	61.4	7	97
8	31	8	47	8	74.5	8	118
9	37	9	56	9	88.0	9	140
10	43	10	65	10	102.3	10	162
11	49	11	74	11	117.0	11	185
12	55	12	84	12	132.2	12	209
13	61	13	93	13	147.7	13	234
14	67	14	103	14	163.6	14	260
15	75	15	113	15	179.6	15	286
16	80	16	123	16	196.0	16	312
17	86	17	133	17	213.0	17	339
18	91	18	144	18	230.0	18	366
19	98	19	154	19	246.5	19	393
20	104	20	164	20	263.4	20	421
21	110	21	174	21	280.3	21	449
22	115	22	184	22	297.0	22	478
23	121	23	194	23	314.0	23	507
24	126	24	203	24	331.0	24	537
25	131	25	213	25	347.8	25	566
26	135	26	222	26	364.5	26	595
27	139	27	231	27	381.0	27	623
28	143	28	239	28	397.0	28	651
29	146	29	248	29	413.0	29	678
30	150	30	256	30	428.4	30	704
		31	263	31	443.6	31	730
		32	270	32	458.3	32	756
		33	276	33	472.5	33	781
		34	281	34	486.0	34	805
		35	285	35	499.2	35	828
		36	287	36	511.4	36	850
				37	523.0	37	872
				38	533.4	38	894
				39	543.0	39	915
				40	551.0	40	935
				41	557.2	41	953
				42	560.0	42	970
						43	984
						44	997
						45	1007
						45½	1012

This chart was developed using a numerical approximation based upon standard tank sizes. For underground tanks only, add 1/2" to dip stick reading because of striker plates in bottom of tank.

ATTACHMENT 8

POLYETHYLENE VERTICAL STORAGE TANKS (T-5 AND T-6)

Polyethylene Vertical Storage Tanks

Part #	Gallons	Diameter	Height	Fill Opening
T1000	65	23″	38″	8″
T10005	100	30″	36″	8″
T1001	120	38″	29″	8″
T1002	165	31″	55″	16″
T1004	220	42″	41″	8″
T1006	300	47″	48″	16″
T1007	300	35″	78″	16″
T1008	305	46″	48″	16″
T1010	500	48″	71″	16″
T1011	525	46″	78″	16″
T1012	550	67″	42″	16″
T10125	675	69″	58″	16″
T1013	750	46″	112″	16″
T1014	1000	64″	79″	16″
T1015	1100	87″	51″	16″
T1016	1300	87″	58″	16″
T1017	1500	64″	115″	16″
T1018	1550	87″	65″	16″
T10181	1610	100″	56″	16″
T1019	1700	87″	70″	16″
T1023	2100	87″	87″	16″
T1024	2500	95″	89″	16″
T1025	3000	95″	105″	16″
T1026	4000	102″	125″	16″
T1027	5000	102″	151″	16″
T[illegible]	5800	141″	97″	16″
T[illegible]	6000	102″	180″	16″
T1030	6500	120″	144″	16″
T1031	9000	141″	144″	16″
T1032	10000	141″	159″	16″
T1034	12000	144″	185″	16″

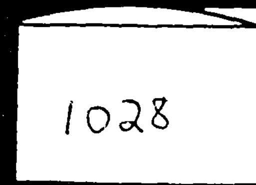
Our polyethylene water and chemical storage tanks out-perform the more expensive, traditional water storage systems for a variety of reasons. Because our tanks are rotationally molded, they are seamless and watertight. They will never rust or corrode and are nearly indestructible. Made of 100% virgin resin listed by the FDA for potable water storage, our polyethylene water tanks contain no colorants. All are efficiently lightweight for easy transportation and installation.

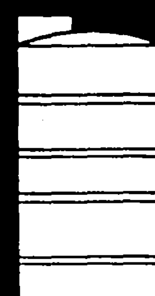
Pickup Truck Tanks

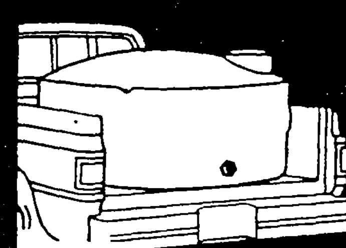
Part #	Gallons	Diameter	Height	Fill Opening
T0900	210	60″/51″	28″	8″
T0901	325	66″	33″	8″
T0902	425	67″	35″	8″

Molded to fit full-size, American-made pickups, the 325 and 425 sizes have low pro-iles for better rear vision and feature fill openings offset to the side of the tank for afe and easy access. Tough circular design adds strength. The 210 gallon tank fits oth "mini" pickups as well as full-size models.

CHEMICAL CONTAINERS, INC.







OPERATIONS AND MAINTENANCE MANUAL
MULTIPHASE RECOVERY SYSTEM
FUEL FARM 216
NAS CORPUS CHRISTI, TEXAS

ATTACHMENT 9

MISCELLANEOUS INFORMATION

HAYWARD INDUSTRIAL PRODUCTS
INSTALLATION OPERATION & MAINTENANCE OF TRUE UNION BALL VALVES

SOCKET CONNECTION:

Socket end connections are manufactured to ASTM D2467-87A. Solvent cementing of socket end connections to pipe should be performed per ASTM specifications D2855-87. Cut pipe square. Chamfer and deburr pipe. Surfaces must be cleaned and free of dirt, moisture, oil and other foreign material. Remove assembly nuts and end connectors from valve body. Slide assembly nuts, with threads facing valve, onto pipe to which the end connector is to be cemented. Apply primer to inside socket surface of end connector. Never allow primer or cement to contact valve ball or end connector o-ring sealing surfaces, as leaking may result. Use a scrubbing motion. Repeat applications may be necessary to soften the surface of the socket. Next, liberally apply primer to the male end of the pipe to the length of the socket depth. Again apply to the socket, without delay apply cement to the pipe while the surface is still wet with primer. Next apply cement lightly, but uniformly to the inside of the socket. Apply a second coat of cement to the pipe, and assemble the end connector to the pipe, rotating the end connector 1/4 turn in one direction as it is slipped to full depth on to the pipe. The end connector should be held in position for approx. 30 seconds to allow the connection to "set". After assembly wipe off excess cement. Full set time is a minimum of 30 minutes at 60 to 100 F. Full cure time should be based on the chart below.

JOINT CURE SCHEDULE:

The cure schedules are suggested as guides. They are based on laboratory test data, and should not be taken to be the recommendations of all cement manufacturers. Individual manufacturer's recommendations for their particular cement should be followed.

Temperature Range During Cure Period(B) °F(°C)	Test Pressures for Pipe Sizes 1/2 to 1-1/4 In.		Test Pressures for Pipe Sizes 1-1/2 to 3 In.		Test Pressures for Pipe Sizes 4 to 5 In.		Test Pressures for Pipe Sizes 6 to 8 In.	
	Up to 180 PSI (1240 kPa)	Above 180 to 370 PSI (1240 to 2550 kPa)	Up to 180 PSI (1240 kPa)	Above 180 to 315 PSI 1240) to 2170 kPa)	Up to 180 PSI (1240 kPa)	Above 180 to 315 PSI (1240 to 2170 kPa)	Up to 180 PSI (1240 kPa)	Above 180 to 315 PSI (1240 to 2170 kPa)
60 to 100 (15 to 40)	1 h	6 h	2 h	12 h	6 h	18 h	8 h	24 h
40 to 60 (5 to 15)	2 h	12 h	4 h	24 h	12 h	36 h	16 h	48 h
20 to 40 (-7 to 5)	6 h	36 h	12 h	72 h	36 h A	4 days A	3 days A	9 days A
10 to 20) (-15 to 7)	8 h	48 h	16 h	96 h	72 h A	8 days A	4 days A	12 days A
Colder than 10 (-15)	Extreme care should be exercised on all joints made where pipe, fittings or cement is below 10°F.							

A: It is important to note that at temperatures colder than 20°F on sizes that exceed 3 in., test results indicate that many variables exist in the actual cure rate of the joint. The data expressed in these categories represent only estimated averages. In some cases, cure will be achieved in less time, but isolated test results indicate that even longer periods of cure may be required.
B: These cure schedules are based on laboratory test data obtained on Net Fit Joints (NET FIT=in a dry fit the pipe bottoms snugly in the fitting socket without meeting interference).

THREADED CONNECTION:

Threaded end connections are manufactured to ASTM specifications D2464-88. F437-88 and ANSI B2.1. Wrap threads of pipe with Teflon tape of 3 to 3-1/2 mil thickness. The tape should be wrapped in a clockwise direction starting at the first or second full thread. Overlap each wrap by, 1/2 the width of the tape. The wrap should be applied with sufficient tension to allow the threads of a single wrapped area to show through without cutting the tape. The wrap should continue for the full effective length of the thread. Pipe sizes 2" and greater will not benefit with more than a second wrap, due to the greater thread depth. To provide a leak proof joint, the pipe should be threaded into the end connection "hand tight". Using a strap wrench only. (Never use a stillson type wrench) tighten the joint an additional 1/2 to 1-1/2 turns past hand tight. Tightening beyond this point may induce excessive stress that could cause failure.

FLANGED CONNECTION:

Flange bolts should be tight enough to slightly compress the gasket and make a good seal, without distorting or putting excessive stress on the flanges. Suitable washers should be used between the bolt head and flange and the nut and flange. Bolts should be tightened in alternating sequence.

RECOMMENDED FLANGE BOLT TORQUE

FLANGE SIZE	BOLT DIA.	TORQUE FT. LBS.	FLANGE SIZE	BOLT DIA.	TORQUE FT. LBS.
1/2	1/2	10-15	2	5/8	15-25
3/4	1./2	10-15	2-1/2	5/8	20-25
1	1/2	10-15	3	5/8	20-25
1-1/4	1/2	10-15	4	5/8	20-25
1-1/2	1/2	10-15	6	3/4	30-40

NOTE: USE WELL LUBRICATED METAL BOLTS AND NUTS. USE SOFT RUBBER GASKETS.

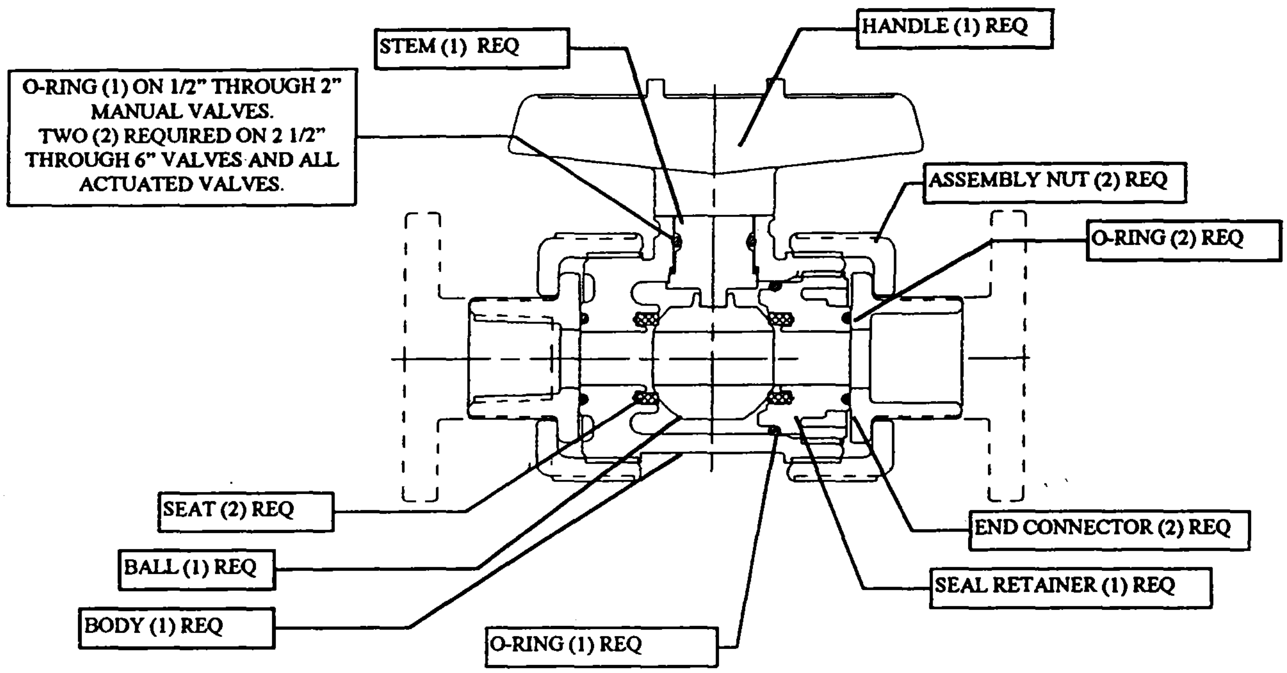
ADJUSTMENT:

EXTREME CAUTION MUST BE TAKEN WHEN WORKING ON THIS VALVE.
THE PIPING SYSTEM MUST BE DEPRESSURIZED AND DRAINED. PROPER CARE MUST BE TAKEN. CONSULT M.S.D.S. (MATERIAL SAFETY DATA SHEETS) INFORMATION REGARDING YOUR SPECIFIC APPLICATION.

Remove the assembly nut and end connector from the "adjust" end of the body, or the complete valve body from the piping system. The front face of the seal retainer indicates which direction of rotation tightens or loosens the seal retainer, with the word "tighten" and a directional arrow, and the word "loosen" and a directional arrow. Direction of rotation may vary depending on date of manufacture. The Assembly nut should be installed on the valve "hand tight". Using a strap wrench <u>only</u> the joint may be tightened 1/2 to 3/4 of a turn past hand tight.

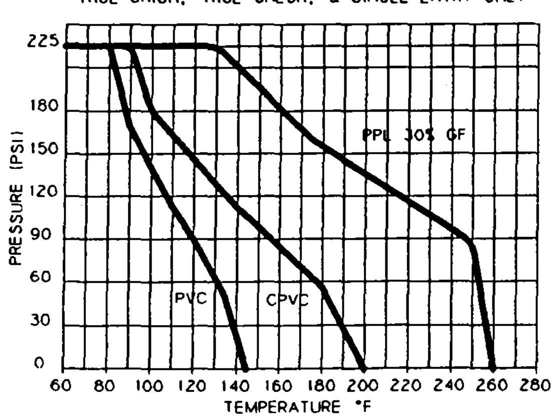
REPAIR:

Follow the adjustment sequence and information above, but rotating the seal retainer completely in the "loosen" direction and remove it from valve body. The o-rings and seals are now accessible for replacement using a "seal" repair kit. Carefully remove the o-rings from their respective locations taking care not to scratch their sealing surfaces. Use a non-petroleum base lubricant to lubricate the o-rings, and re-assemble the valve. See table below.



OPERATING PRESSURE
TEMPERATURE

TRUE UNION, TRUE CHECK, & SINGLE ENTRY ONLY



Recommended valve stem torque to rotate the ball 360° when valve is reassembled.

VALVE SIZE	TORQUE IN*LB
1/2"	30
3/4"	40
1"	50
1 1/4"	60
1 1/2"	60
2"	80
3" & 2 1/2"	140
4" & 6"	170

INSTALLATION, OPERATION AND MAINTENANCE
HAYWARD ELECTRIC ACTUATORS
ALL MODELS

WITH THE HAYWARD PRE-MOUNTED AND FACTORY TESTED, ELECTRIC ACTUATOR, MOUNTING KIT AND VALVE ASSEMBLY, THE FIRST REQUIREMENT FOR PROPER INSTALLATION IS TO:

1.DISCONNECT POWER SUPPLY !

2.REMOVE THE ACTUATOR COVER.

INSIDE THE COVER YOU WILL FIND ALL OF THE APPROPRIATE WIRING DIAGPAM INFORMATION TO ALLOW YOU TO PROPERLY INSTALL EACH ACTUATOR. ON THOSE MODELS REQUIRING MORE THAN FOUR (4) COVER SCREWS, THE ADDITIONAL SCREWS ARE PACKAGED IN A POLYBAG INSIDE THE ACTUATOR.

THE INSTALLATION WIRING DOCUMENTATION HAS BEEN PLACED INSIDE THE ACTUATOR IN THE FORM OF A LABEL AFFIXED TO THE INSIDE OF THE TOP COVER OR PRINTED ON A FOLDED INSTALLATION, OPERATION SHEET.

SHOULD YOU HAVE PURCHASED AN ACTUATOR WITH MULTIPLE OPTIONS, WE MAY HAVE PLACED THE ADDITIONAL INSTALLATION OPERATION DOCUMENTATION INTO A HEAT SEALED POLYBAG PLACED WITHIN THE SHIPPING CARTON. LOOK CAREFULLY INSIDE THE CARTON TO BE SURE THAT YOU DO NOT ACCIDENTLY DISCARD THESE IMPORTANT DOCUMENTS.

COMPLIANCE OF LOCAL BUILDING/ELECTRICAL CODES:

THE ELECTRICAL CONNECTIONS TO THE ACTUATOR MUST BE PROPERLY CONNECTED CONSISTANT WITH THE INSTALLATION SCHEMATIC(S) TO THE TERMINAL STRIP(S) AFFIXED WITHIN THE ACTUATOR, OR IN CASES WHERE MULTIPLE ADDITIONAL LIMIT SWITCHES HAVE BEEN INSTALLED, TO THE WIRE LEADS WITH PROPERLY SIZED WIRE CONNECTORS AS REQUIRED BY CODE.

ALL HAYWARD ELECTRIC ACTUATORS CARRY A TWO (2) YEAR WARRANTY FOR MATERIAL DEFECTS AND WORKMANSHIP.

ACTUATOR COUPLING

DO NOT USE COUPLINGS OTHER THAN THAT SUPPLIED WITH THIS VALVE/ACTUATOR COMBINATION FOR INTERFACE BETWEEN THE ACTUATOR AND THE VALVE.

IMPORTANT TORQUE NOTICE

WHEN ATTACHING HAYWARD PLASTIC MOUNTING BRACKETS TO HAYWARD VALVES, THE FOLLOWING TORQUE SPECIFICATIONS FOR TIGHTENING OF ACTUATOR MOUNTING BRACKET BOLTS TO VALVES SHOULD BE FOLLOWED:

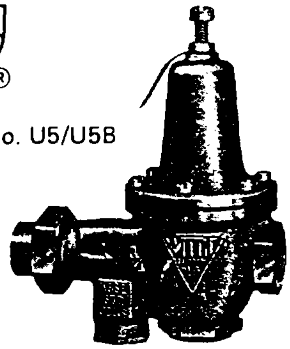
BALL VALVES:

BOLT SIZE	VALVE SIZE	TORQUE SPECIFICATION
1/4" THREAD	1/4" THRU 2"	25 TO 30 INCH POUNDS
3/8" THREAD	2 1/2" THRU 6"	70 TO 90 INCH POUNDS

BUTTERFLY VALVES:

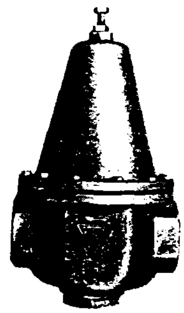
BOLT SIZE	VALVE SIZE	TORQUE SPECIFICATION
3/8" THREAD	1/2" THRU 12"	100 TO 140 INCH POUNDS

INSTRUCTIONS FOR INSTALLING
Watts Water Pressure Reducing Valves

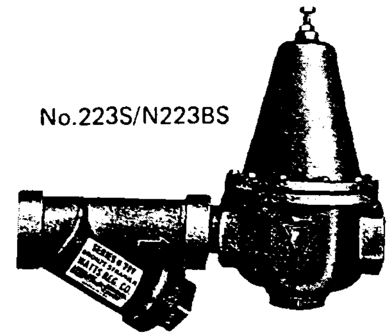


No. U5/U5B

Series U5 only
IAPMO listed



No. 223/N223B



No.223S/N223BS

INSTALL THE VALVE IN THE LINE WITH THE SUPPLY CONNECTED TO VALVE INLET (MARKED "IN" ON CASTING) OR WITH THE ARROW ON THE VALVE BODY POINTING IN THE DIRECTION OF FLOW.

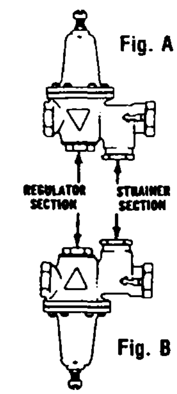
These regulators can be installed horizontally in either an upright or inverted position, as shown or vertically and is a matter of choice of accessibility for servicing the regulator. For example, in an upright position (Figure A) the strainer area, on valves so equipped, can more easily be cleaned out by removing the bottom plug and any collected sediment will fall downwards. Accessibility for servicing the regulator section, however, may be less convenient.

When the valve is installed in an inverted position (Figure B), the "regulator section" is more readily exposed for simplified servicing of the disc and seat, while the strainer can almost as easily be flushed out by turning the water supply on slightly.

NOTE: Regulator must always be installed in an accessible location to facilitate servicing.

For household use install the reducing valve, when possible so that the sill cock line is after or downstream of the reducing valve as shown in diagram below. Before installing the reducing valve flush out the line to remove loose dirt and scale which might damage valve disc and seat. On valves having strainers the screen should be removed and cleaned at least once every six months, more often if water conditions are bad.

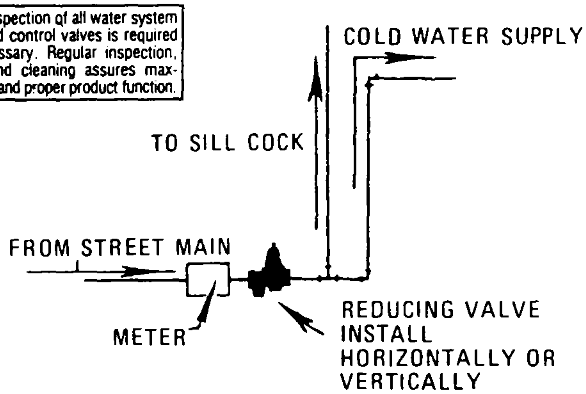
TO READJUST reduced pressures, loosen check nut and turn adjusting screw clockwise to raise reduced pressure and counter clockwise to lower reduced pressure.



When a reducing valve is used it makes a closed system; therefore, pressure relief protection must be provided on the downstream side of the regulator to protect equipment.

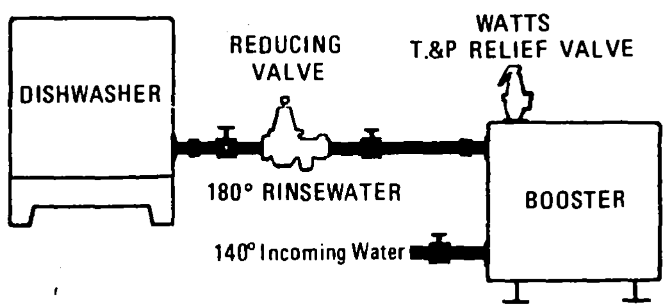
MAIN LINE SERVICE

Annual inspection of all water system safety and control valves is required and necessary. Regular inspection, testing and cleaning assures maximum life and proper product function.



LOW PRESSURE SERVICE

Recommended installation when regulator is used to control flow through the booster heater to dishwasher.



"ATTN. INSTALLER: After installation, please leave this Instruction Sheet for occupant's information."

CALIFORNIA PROPOSITION 65 WARNING

This product contains lead, a chemical known to the State of California to cause birth defects or other reproductive harm.

(Plumber: California law requires that this warning be given to the consumer.)

CONSUMER INFORMATION ABOUT CALIFORNIA PROPOSITION 65 WARNING

All faucets and products made of leaded brass alloys, even those that comply with U.S. Environmental Protection Agency regulations, contribute small amounts of lead to water that is allowed to stand in contact with the brass. This product complies with all E.P.A. regulations regarding the amount of lead used in plumbing brass and solder. The amount of lead contributed by any faucet/product is highest when the faucet/product is new.

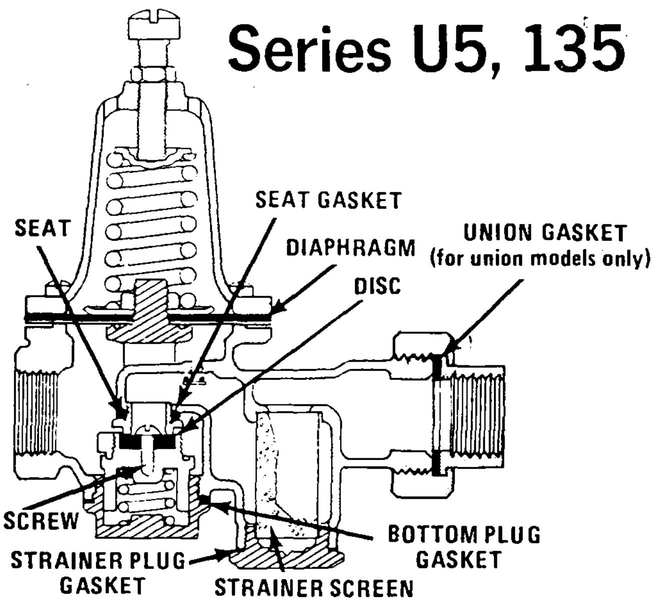
The following steps will reduce potential exposure to lead from faucets and other parts of the plumbing system:

- Always run the water for a few seconds prior to use for drinking or cooking.
- Use only cold water for drinking or cooking.
- If you wish to flush the entire plumbing system of water that has been standing in the pipes or other fittings, run the cold water until the temperature of the water drops, indicating water coming from the outside main.
- If you are concerned about lead in your water, have your water tested by an EPA-certified laboratory in your area.

Repair Kits...

When ordering, specify **Ordering Code Number, Kit Number and Valve Size.**

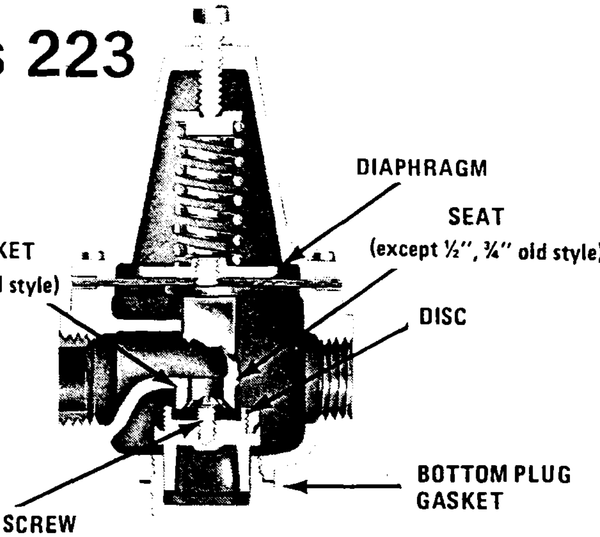
Series U5, 135



Kit for No. U5, 135 includes parts shown above

Ordering Code No.	Kit No.	Valve Series	Size Inches
861460	"A"		½
861465	"B"		¾
861470	"C"	U5	1
861475	"D"		1¼
861477	"E"		1½
861480	"F"		2, 2½
861460	"A"		½
861465	"B"	135	¾
861480	"F"		1½

Series 223



Kit for No. 223 includes parts shown above

Ordering Code No.	Kit No.	Valve Series	Size Inches
877104	½/223RK		½
861470	"C"		¾
861475	"D"		1
861477	"E"	223	1¼
877494	1½223RK		1½
877500	2 223RK		2
877551	2½223RK		2½
877555	2½ N223RK	N223B	2½ Bronze
878305	3 N223RK	N223B	3 Bronze

WATTS "THERMAL EXPANSION BY-PASS MODEL" WATER PRESSURE REGULATORS SERIES U5B, N223B

The use of a water pressure reducing valve normally creates a closed system. When water is heated in a closed system, it expands causing an increase in pressure. This pressure may increase to the set pressure of the relief valve (on the water heater) causing it to drip, thus releasing the expanding water and protecting the system against excessive pressure. This increase in the system pressure over that regulated by the reducing valve is called "thermal expansion pressure".

Watts Thermal Expansion By-Pass Model water pressure reducing valves, U5B and N223B are an economical solution of this annoyance, since under certain conditions it allows the expanding water to escape back into the supply main before it can affect the relief valve.

Effectiveness of the Thermal Expansion by-pass feature is limited to systems where the street main pressure is less than the setting of the heater relief valve. Therefore, the highest **allowable** pressure setting for the relief valve should be selected for widest effectiveness of a by-pass.

When approved by local authorities, 150 lb. pressure relief setting is recommended in accordance with latest allowable pressure standards for gas and electric water heaters.

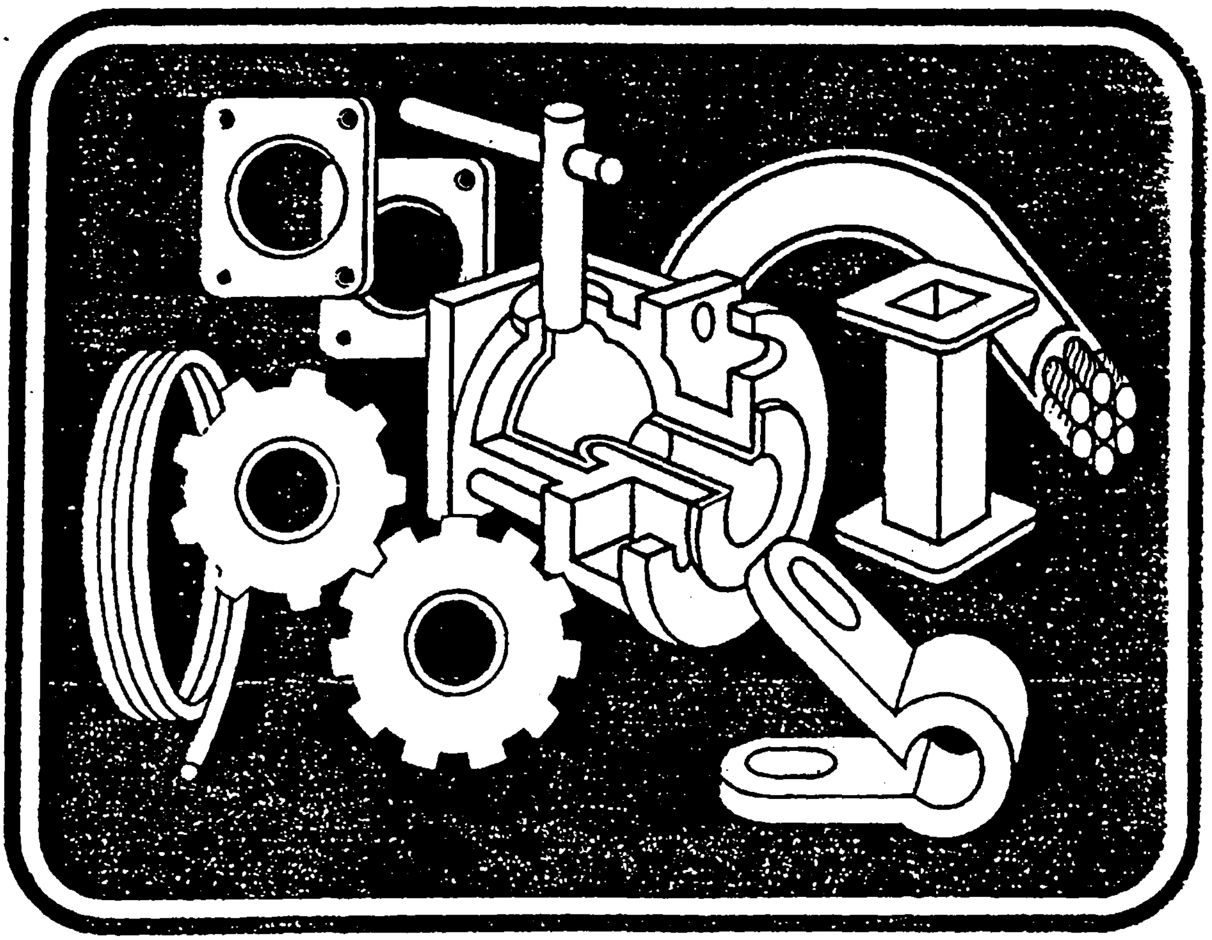
A LEADER IN VALVE TECHNOLOGY
WATTS REGULATOR
Since 1874 — Watts Industries, Inc.
Water Products Division • Safety & Control Valves
USA: 815 Chestnut Street, North Andover, MA 01845-6098
Canada: 441 Hanlan Rd. Woodbridge, Ontario L4L 3T1
ISO 9001 CERTIFIED

LIMITED WARRANTY: Watts Regulator Company warrants each product against defects in material and workmanship for a period of one year from the date of original shipment. In the event of such defects within the warranty period, the Company will, at its option, replace or recondition the product without charge. This shall constitute the exclusive remedy for breach of warranty, and the Company shall not be responsible for any incidental or consequential damages, including without limitation, damages or other costs resulting from labor charges, delays, vandalism, negligence, fouling caused by foreign material, damage from adverse water conditions, chemicals, or any other circumstances over which the Company has no control. This warranty shall be invalidated by any abuse, misuse, misapplication or improper installation of the product. THE COMPANY MAKES NO OTHER WARRANTIES EXPRESS OR IMPLIED EXCEPT AS PROVIDED IN THIS LIMITED WARRANTY.

DU PONT

TEFZEL

FLUOROPOLYMER



PRODUCT DATA

TEFZEL 200, 210 & 280

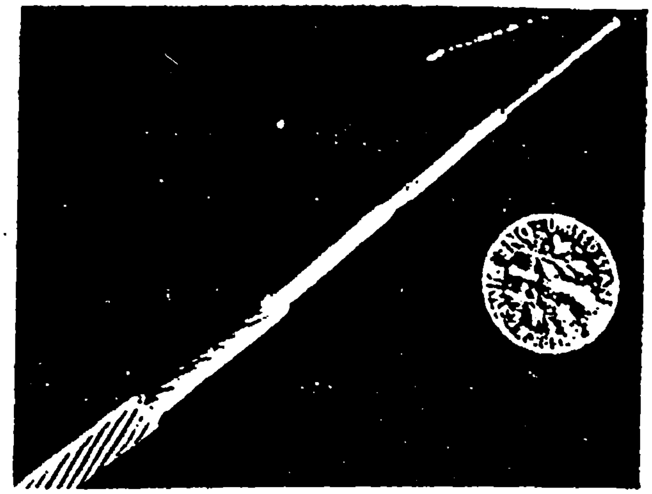
INTRODUCTION

Du Pont TEFZEL® fluoropolymers are melt processible thermoplastics with high performance mechanical, thermal, chemical and electrical properties. Their outstanding properties and ease of processing provide excellent service and significant use and processing economies.

PRODUCT DESCRIPTION

TEFZEL fluoropolymer resins are copolymers of ethylene and tetrafluoroethylene. They are high temperature thermoplastics readily processed by conventional methods such as melt extrusion and injection molding. Compared to other high performance resins, TEFZEL permits faster processing rates resulting in economically finished products. TEFZEL is recommended for applications requiring mechanical toughness in harsh chemical and high temperature environments.

The types of TEFZEL fluoropolymer resins are:



Well logging cable

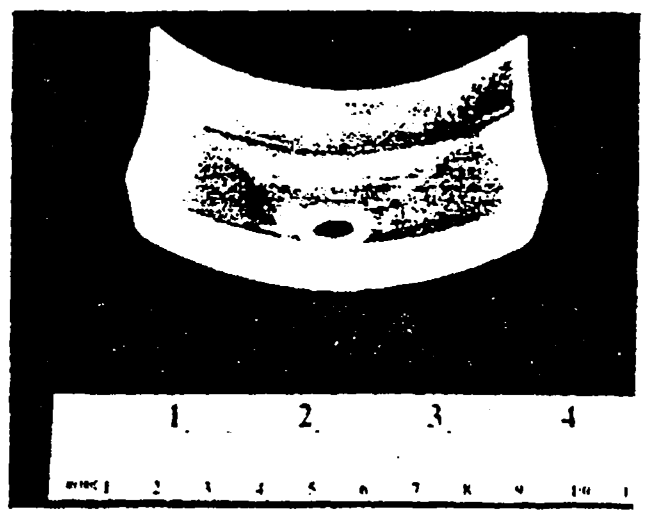
TEFZEL 200

A general purpose resin used in a variety of electrical, chemical and mechanical applications.

In electrical applications it is used for signal, control, communication and power wiring in mass transportation; in back panel wiring; oil well logging cable; in control and instrumentation wiring for chemical plants and utilities; and to injection mold coil forms, sockets, connectors, switch components and insulators.

The excellent mechanical properties of TEFZEL provide good service in items such as seal glands, pipe plugs, corrugated tubing, fasteners and pump vanes.

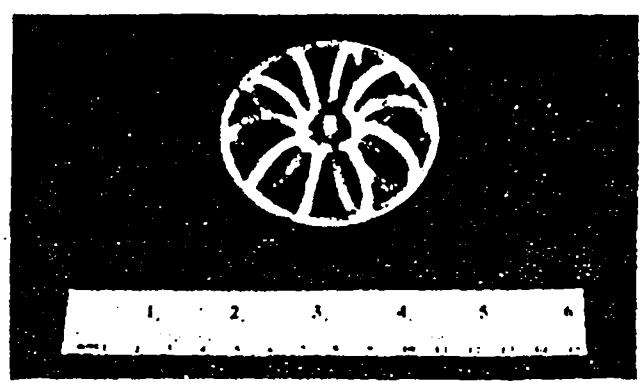
In chemical service TEFZEL is used for such things as valve components, laboratory ware, chemical packings, pump impellers and battery and instrument components.



Chemical pump drip pan

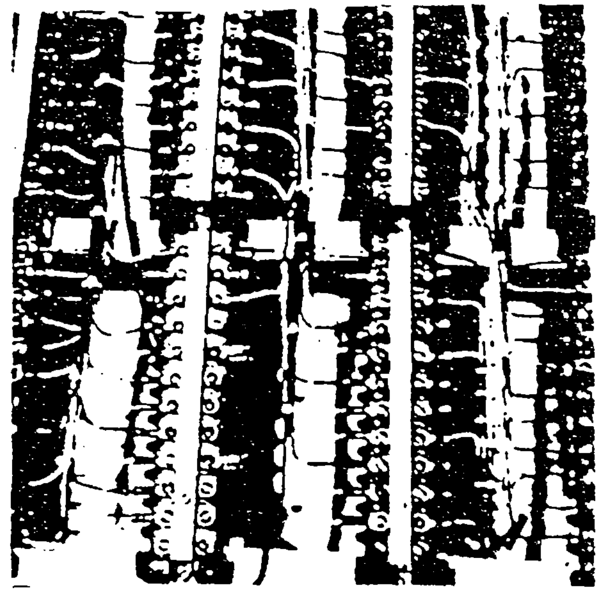
TEFZEL 210

The newest member of the TEFZEL fluoropolymer family with the lowest viscosity provides the user with a high speed processing resin making it especially appropriate for use in coating of fine wire and injection molding of slender, thin-walled or intricate shapes. This resin is not recommended for applications where mechanical integrity in high temperature environments is required.



Column packing

Valve body lining



Control wire insulation

TEFZEL 280

Recommended for applications or processing involving unusual thermal and mechanical extremes. TEFZEL 280 offers high flex life and stress crack resistance along with good transparency.

Typical uses are for wire and cable insulation where temperatures up to 200°C are experienced for short periods or where repeated mechanical stress may be encountered at 150°C; transfer moldings and extrusions for lined chemical equipment; injection molded parts with metal inserts; thick sections or where the part will be exposed to repeated high temperature stress; heavy wall wire and cable insulations; and, stock shapes.

TYPICAL PROPERTIES

PROPERTY	UNITS	ASTM TEST	TEFZEL® 200	TEFZEL® 210	TEFZEL® 280
Specific Gravity		D792	1.70	1.70	1.70
Tensile Strength, 73°F	psi	D1708	6500	6000	7500
Elongation, 73°F	%	D1708	100-300	100-300	100-300
Flexural Modulus, 73°F	psi	D790	200,000	170,000	200,000
Flex Life, MIT, 10 Mil	Flexes		5,500	5,500	12,000
Impact Strength (notched izod)					
−65°F	ft. lb./in.	D256	> 20	> 20	> 20
73°F			No Break	No Break	No Break
Coefficient of Friction					
> 10 fpm, 100 psi			0.4	0.4	0.4
Hardness, Durometer		D2240	D75	D75	D75
Rockwell			R50	R50	R50
Dielectric Constant @ 10^2 Hz		D150	2.6	2.6	2.6
10^3 Hz		D150	2.6	2.6	2.6
10^6 Hz		D150	2.6	2.6	2.6
Dissipation Factor @ 10^2 Hz		D150	0.0006	0.0006	0.0006
10^3 Hz		D150	0.0008	0.0008	0.0008
10^6 Hz		D150	0.005	0.005	0.005
Dielectric Strength, Short Term					
125 Mils	Volts/mil	D149	400	400	400
10 Mils	Volts/mil	D149	> 2000	> 2000	> 2000
Volume Resistivity	OHM-CM	D257	$> 10^{16}$	$> 10^{16}$	$> 10^{16}$
Surface Resistivity	OHM/SQ	D257	$> 10^{14}$	$> 10^{14}$	$> 10^{14}$
Melting Point, DTA Peak			270°C (520°F)	270°C (520°F)	270°C (520°F)
Temperature Index (Nominal Temperature Rating)			150°C (302°F)	135°C (275°F)	150°C (302°F)
Flammability*		UL-94	VO	VO	VO
Heat Distortion @ 66 psi		D648	105°C (220°F)	105°C (220°F)	105°C (220°F)
@ 264 psi		D648	70°C (160°F)	70°C (150°F)	70°C (160°F)
Coef. of Linear Thermal Exp.					
Per °F, (73-167°F)		D696	7.6×10^{-5}	7.6×10^{-5}	7.6×10^{-5}
Low Temperature Embrittlement		D746	< −100°C (−150°F)	< −100°C (−150°F)	< −100°C (−150°F)
Water Absorption	%	D570	< 0.03	< 0.03	0.03
Weather Resistant			Excellent	Excellent	Excellent
Chemical Resistance			Excellent	Excellent	Excellent
Resistance to Hydraulic Fluids			Excellent	Excellent	Excellent

PROCESSING CHARACTERISTICS

PROPERTY	UNITS	ASTM TEST	TEFZEL® 200	TEFZEL® 210	TEFZEL® 280
Melt Flow Number	gms/10 min.	D3159	6-11	30-65	2-5
Processing Temp. Range	°F		575-625	600-650	600-650

*For unpigmented thicknesses down to 1/16 inch

PROCESSING

three TEFZEL resins are tough, high temperature, melt ,cessible thermoplastics that can be processed by conventional methods such as injection molding, transfer molding, compression molding, melt extrusion, etc. Because it is a conventionally processed thermoplastic, TEFZEL has gained quick acceptance among molders and wire coaters. It is readily extruded over aluminum or copper wire plated with tin, nickel or silver. Coloring is achieved by adding a TEFZEL color concentrate.

Du Pont has increased the ease and speed of processing with the introduction of TEFZEL 210. Molders are particularly impressed with the ability of this resin to be molded at high rates into thin-walled, intricate shapes.

PROPERTIES

TEFZEL resins are tough, high-temperature thermoplastics with excellent chemical resistance and electrical insulating properties (see typical properties table).

AVAILABILITY

Each resin is available in 25-pound "Fiberpacks" with removable polyethylene bag; 100-pound "Leverpaks" with two removable polyethylene bags of 50 pounds each; or 1,000-pound pallets of ten 100-pound "Leverpaks".

FREIGHT CLASSIFICATION

TEFZEL fluoropolymer resin is shipped by rail classified as "Plastics, Synthetic, OTL, NOIBN", by truck as "Plastics Materials, Granules", by express as "Plastics, Synthetic".

SAFE HANDLING

It is recommended that all safety precautions taken with the handling and processing of TEFLON® FEP be followed when handling or processing TEFZEL.

As with all organic polymers exposed to high temperatures, good safety practice requires the use of adequate ventilation. The heated fluoropolymer should be kept enclosed or exhaust ventilation should be used to prevent inhalation of fumes and gases that may arise. Heating may produce fumes and gases that are irritating or toxic. Similarly, care should be taken to avoid contamination of smoking tobacco or cigarettes with fluorine-containing resins.

E. I. du Pont de Nemours & Co. (Inc.)
Plastic Products and Resins Department
Fluorocarbons Division
Wilmington, Delaware 19898

DISTRICT OFFICES:

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Basking Ridge, New Jersey 07920

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Farmers Bank Building, 15th Floor
Wilmington, Delaware 19898

P. O. Box 8950, 80 Universal City Plaza
Universal City, California 91608

Temperature Control

Types of Controllers

On/off control: A simple control system in which the device being controlled is either completely on if there is a deviation from set point, or completely off if you are at the set point or within the hysteresis.

Proportional(P) control: Control in which the value of the control output is proportional to the deviation from the set point. When the process variable enters the proportional band, the control output decreases as your process variable approaches the set point. Usually, the control output will be 50% when you reach the set point.

Integral(I) control: Control that corrects for a "droop" or offset condition which can occur when using only proportional control. Occurs only within the proportional band. The deviation from set point is integrated over a selected time interval and added to the proportional signal in order to move or "reset" the proportional band. The selected time interval is sometimes called the number of resets per minute. Usually used with proportional control for proportional-integral(PI) control.

Derivative(D) control: Control in which the value of the control output is dependent on the rate of increase (or decrease) of the process variable from the set point. The derivative of the deviation from set point is taken and added to the proportional signal. Always used with at least proportional control for proportional-derivative(PD) control. Helps prevent overshoot during process disturbances.

PID control: Proportional-integral-derivative control. Control in which the value of the control output is a linear combination of the error signal, its integral and its derivative. Provides precise control and is used for systems that have frequent disturbances.

Fuzzy logic PID: Uses a set point modifier to create a temporary set point that allows the controller to recover more quickly and smoothly. The temporary set point changes continuously as you get closer to the actual set point, so that overshoot at start-up and during process disturbances is virtually eliminated. Optimizes system performance.

Table of Contents

Output Types

SPST relay: Single pole, single throw relay. An electrically controlled mechanical switch that either opens or closes a circuit

SPDT relay: Single pole, double throw relay. An electrically controlled mechanical switch that in one position closes a circuit, and in the second position, closes another circuit, breaking the first.

SSR: Solid state relay. A electrically controlled switch that has no moving parts. The switching action is done through a transistor. Silent operation and longer lifetime than a SPDT relay. External SSRs are used for systems that have a high current draw, which might be too high for a relay that is built into the controller.

Pulse output for SSR: A logic signal that is used to actuate an external SSR. See page 1211 for our external SSRs.

Analog output: Usually a 4-20 mA signal or a voltage signal that is proportional to the temperature reading.

Powered output: Usually a three prong receptacle that provides 115 VAC power (or 230 VAC, depending on controller) to heating or other control devices.

MORE INFO

For heaters that can be used with our temperature controllers, see our "Heating Equipment" section on pages 410-427

HOT TIP

Output devices should not share a common ground with controllers or inputs.

Compact Temperature Switches

- *Perfect to control system temperatures or to act as a final safety shutoff*
- *Direct-acting—additional instrumentation, power, or amplification are not required*

These electromechanical temperature switches are designed for use in rigorous industrial or laboratory conditions to control overheating of air compressors, distilling machines, and other equipment. A bimetal snap disc reverses from convex to concave upon reaching temperature trip point, which activates a SPDT microswitch.

This double-snap action makes switches practically shockproof and vibration proof. Epoxy sealing further shockproofs the switches. Thin switch base allows good heat conductivity—when snap disc cools, microswitch reverts back to normal position.

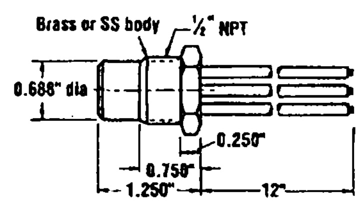
Three-wire design allows you to wire SPDT relay for either normally open (NO) or normally closed (NC) operation.

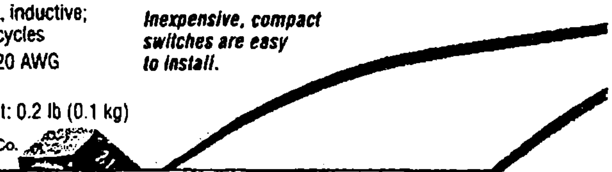
Simple to install—switches require very little wiring and don't need shock mounts. Switches are compact enough to easily thread into any ½" NPT opening. Choose from brass or stainless steel.

Specifications

Repeatability: ±3°F (±2°C) at standardized conditions
Dead band: 15°F, ±5°F (8°C, ±3°C), nonadjustable
Control output: SPDT relay rated for 28 VDC or 120 VAC, 5 A max, resistive, 3 A max, inductive; 220 VAC, 5 A max, resistive. 50,000 cycles
Electrical connections: 3 wires, 12"L, 20 AWG stranded, Teflon® insulation
Dimensions: 1¼"L x 11/16" dia Shpg wt: 0.2 lb (0.1 kg)

Teflon—Reg TM E. I. du Pont de Nemours & Co.



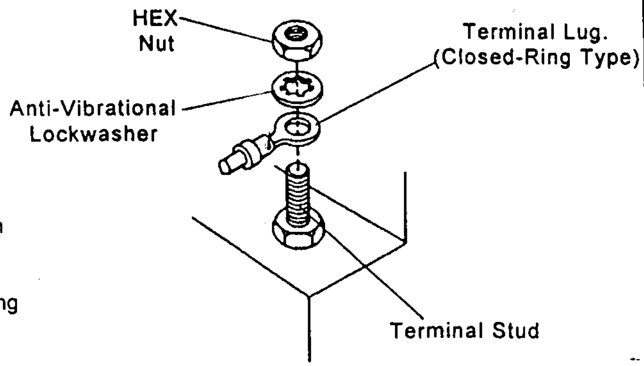


Inexpensive, compact switches are easy to install.

Temperature trip point	Brass		Stainless steel	
	Catalog number	Price	Catalog number	Price
75°F (24°C)	E-93880-00	$55.00	E-93880-50	$65.00
100°F (38°C)	E-93880-02	55.00	E-93880-52	65.00
125°F (52°C)	E-93880-04	55.00	E-93880-54	65.00
150°F (66°C)	E-93880-06	55.00	E-93880-56	65.00
200°F (93°C)	E-93880-08	55.00	E-93880-58	65.00
225°F (107°C)	E-93880-10	55.00	E-93880-60	65.00
250°F (121°C)	E-93880-12	55.00	E-93880-62	65.00

G. Refer to Fig. 6 for detailed connection to terminal studs. All hardware, including terminal lugs, is supplied with unit.

Fig. 6. Recommended Method of Connection to Electrical Terminals



Notes

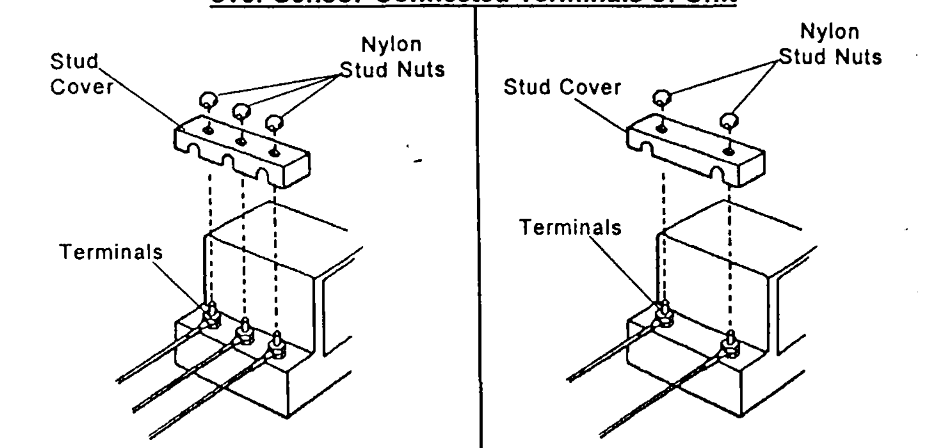
Tighten Assembly to Between 3 and 5 In. Lbs.

All terminal hardware (including lug) supplied with unit.

H. Fusing of the SAFE-PAK to be in accordance with Fig. 1. Fuse F1 to be 6 amps "slo-blo". 120 VAC for 120 V line voltage; 250 VAC for 240 volt application.

I. Protective cover (supplied) must be in place over sensor-connected terminals of the PAK after wiring has been completed. (See Fig. 7)

Fig. 7. Mounting of Protective Cover over Sensor-Connected Terminals of Unit



LATCHING SAFE-PAK | SAFE-PAK

P/N 54477
Rev. AA

Gems Sensors
One Cowles Road
Plainville, CT
06062.1198

tel 860.747.3000
fax 860.747.4244

SAFE-PAK Models 22445, 25872, 25873
Latching SAFE-PAK Models 41705, 41715
HI-LO PAK Models 38705, 38710, 38715, 38720

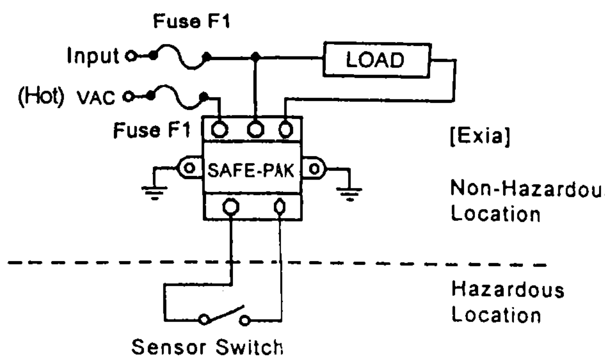
Instruction Bulletin No. 54477

For use as an "intrinsically safe switch circuit" and in hazardous locations with non-voltage producing sensors. When SAFE-PAK installation is in accordance with this guide, these field sensors are suitable for Class I; Division 1, 2; Groups A, B, C and D and Class II; Division 2; Groups E, F and G as defined by Article 500 of the National Electric Code.

IMPORTANT!
Read carefully and completely before installing or connecting SAFE-PAK, LATCHING SAFE-PAK or HI-LO PAK units:

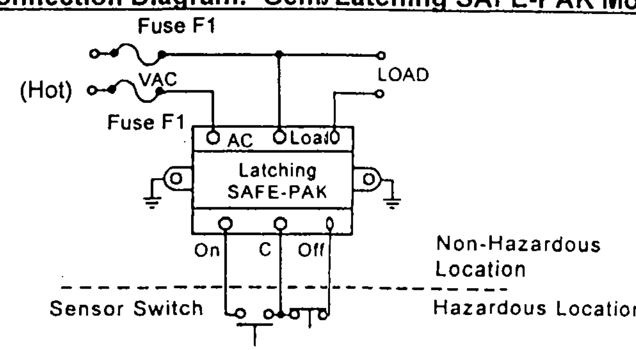
1. Associated Equipment - Caution: The SAFE-PAK must be mounted outside the hazardous area. Only the switch or sensor terminals provide an intrinsically safe switch circuit (see Fig. 1 or Fig. 2). [Exia] means associated equipment: "Appareillage connexe", located in safe area.

Fig. 1. Connection Diagram: Gems SAFE-PAK Models



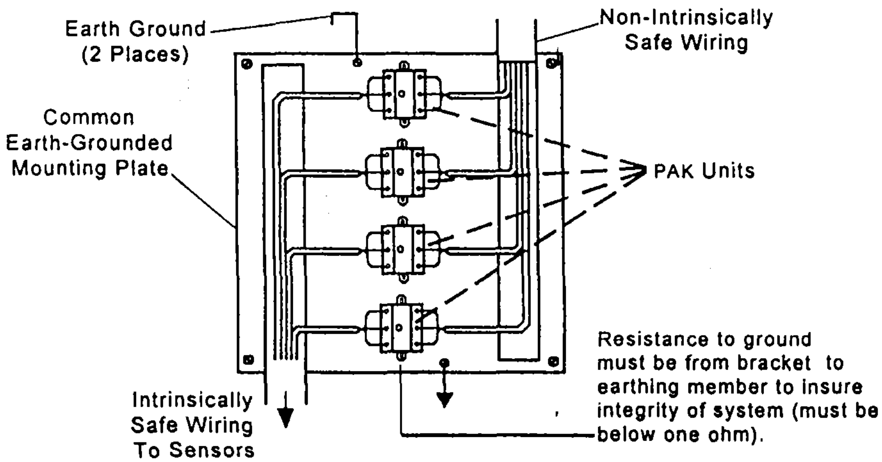
Note: For 120V application, only one fuse is required in the ungrounded circuit of the input line.

Fig. 2. Connection Diagram: Gems Latching SAFE-PAK Models



2. Mounting and Enclosure Considerations:
   A. Field wiring of intrinsically safe circuits is to be segregated from non-intrinsically safe wiring by use of suitable barriers, separate wireways or trays (See Fig. 3). Wire insulation to be .010" minimum.

Fig. 3. Multiple PAK Units Grouped on Common Earth-Grounded Mounting Plate



Note: All intrinsically safe wiring must be segregated from non-intrinsically safe wiring and shall have a minimum insulation thickness of .010".

   B. Intrinsically safe and non-intrinsically safe connection points should be located sufficiently apart to prevent any possibility of bypassing or miswiring during installation or servicing of equipment.

   C. The enclosure shall contain a cautionary statement as follows: "CAUTION: ANY SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY".

   D. The PAK mounting bracket must be grounded to insure intrinsic safety. Resistance between bracket and ground electrode should be below one ohm. (See Fig. 4 and Fig. 5 for recommended selection of grounding hardware and refer to Article 250 of the National Electrical Code for methods and practices.)

Fig. 4. Unit Mounting Detail

*Note: Lockwashers to be internal or external tooth-type.

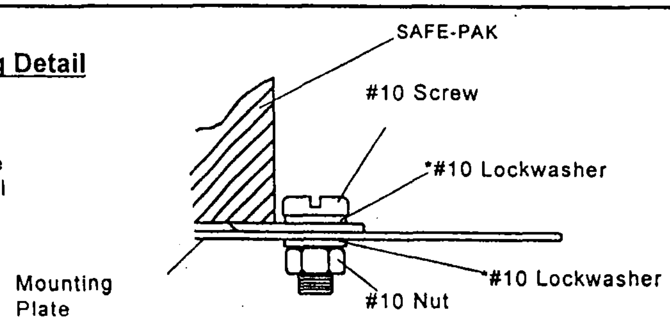
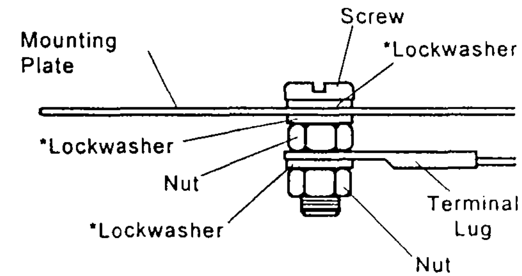


Fig. 5. Mounting Plate Grounding Detail

Notes
Grounding Hardware to be #8 or larger and Stainless Steel.

*Lockwashers to be internal or external tooth type.



3. Installation of Sensor Switch and Running of Field Wiring:

   A. The nature of the sensor switch must be that it is a non-voltage-producing, essentially resistive device, containing no energy-storing components.

   B. The conductors of the intrinsically safe circuit should be sealed in a rigid metal conduit at the point where the wiring enters the hazardous area. The wiring and contacting device should be such that conductive dusts in the area will not close the circuit in place of the contacts.

   C. Hazardous area field wiring will store energy due to distributed capacitance and inductance in proportion to its length. It is therefore recommended that the characteristics (available from the manufacturer) of the cable be known and judged against the length of run and atmosphere of exposure. The following conservative chart is presented as a guideline in determining the limits of reactance for signal loops in the hazardous area wiring for the SAFE-PAK series.

GROUP	CAPACITANCE	INDUCTANCE
A & B	0.1 uf	3 mh
C	0.2 uf	10 mh
D	0.3 uf	20 mh

Example: Typical values of capacitance for a twisted pair of copper wires is between 20 and 60 pf per foot. Using a maximum value of 60 pf/Ft, groups A & B could have a run of 1500+ feet with safety. Inductance of a typical twisted pair is between 0.10 and 0.20 uh/Ft, thus making a cable run in this example essentially determined by the capacitance.

   D. Whenever possible, the actual measured parameters should be used in making the determination of allowable length.

   E. Shielded cable is not required; but if used in the application, the shield must be returned to ground - the same as the PAK mounting bracket.

   F. Non-intrinsically safe wiring cannot be run in conduit or open raceways together with intrinsically safe wiring.

3rd Step – continued

HI-LO PAK, 2 versions:

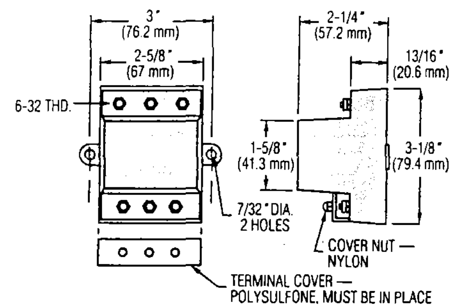
1. 0.3 amp Version:
Solid-state switched outputs with these approvals:
U.L.-Approved intrinsically safe for Class I, Groups A, B, C, D and Class II, Groups E, F, G, File #E44570.
MSHA-Approved to requirements of Schedule 2G under File #1662.

2. 1 amp Version:
Features electromechanically switched outputs, without above approvals.

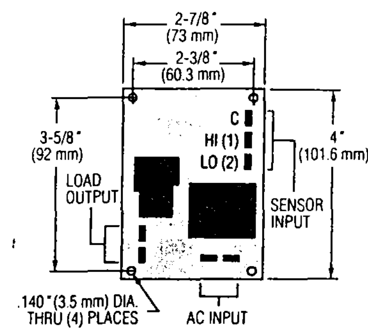
These units are bracket mounted in a non-hazardous location with the bracket maintained at ground potential. The protective cover (supplied) must be in place over the sensor terminals after wiring has been completed. Ordinary commercial signal wire may be used to connect the sensor, with no explosion-proof housings of any kind needed, an important time and cost saver.

Open Board Controller, 10 amp.
Features electromechanically switched outputs. Cost-effective for use in non-hazardous applications and mounting in customer's enclosures. Can be installed in a panel or other housing and connected to the sensor terminals by signal wire.

HI-LO PAK



Open Board Controller



Specifications

	HI-LO PAK		Open Board Controller
	0.3 amp	**1 amp**	
Ambient Temp. Range	-40°F to 120°F (-40°C to 49°C)		-40°F to 140°F (-40°C to 60°C)
"OFF" Max. Current Leakage (mA)	5		3
Switched Output, Load Current, Maximum (amps,RMS)	0.3	1	10
"ON" Voltage Drop, Max. (VAC, RMS)	2	—	—
Switched Voltage (VAC, RMS)	120	120	120
Electrode Current, Max.	Intrinsically Safe	—	200 µA

Type	Output Current (Amps, RMS)	Input[1] Voltage (VAC, ± 10%)	Output Circuit	Function*	Max. Media[2] Resistance (K ohms)	Part Number
0.3 amp HI-LO PAK (Model 38700)	0.3	120	NO	P-D	10	**112291** ⚡
			NC	P-U	10	**112293** ⚡
			NO	P-D	50	**112292** ⚡
			NC	P-U	50	**112294** ⚡
1 amp HI-LO PAK (Model 87900)	1		NO	P-D	10	**112295** ⚡
			NC	P-U	10	**112297** ⚡
			NO	P-D	50	**112296** ⚡
			NC	P-U	50	**112298** ⚡
Open Board Controller	10	120	NO	P-D	25	**119865**
			NC	P-U	25	**119861**
			NO	H-L	25	**119869**
			NC	L-L	25	**119873**

* P-D = Pump Down; P-U = Pump Up; L-L = Low Level; H-L = High Level.
Notes: 1. Consult factory for available 240 VAC style.
2. Consult factory for other resistance values that are available.

⚡ – Stock Items.

FaxPress Info

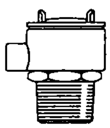
For a list of resistance factors of common liquid substances, order FaxPress Info #B200. See Page Z-2 for details. 1-860-747-4244.

How To Order

For a complete GEMS conductivity system, just follow these three steps.

1st ▶ Choose the Conductivity Sensor terminal head unit that best suits your application.

See Typical Wiring Diagrams on previous page.

Description	Mounting Material	Operating Temperature	Operating Pressure	Part Number
 1/2"NPT Mounting with Single Electrode (Open Terminal)	303/304 Stainless Steel	400°F (205°C)	100 psi @ 225°F (107.2°C)	**110821**
 2"NPT Mounting with triple Electrode adapter. Watertight GUA Junction Box.	303/304 S.S.		100 psi @ 400°F (205°C)	**114806**
	Brass			**114802**

Other wetted parts: Epoxy.

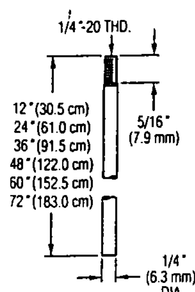
2nd ▶ Select Electrode length required.

GEMS electrodes provide broad chemical compatibility. They are easily unscrewed and replaced when long-term chemical corrosion is excessive. An occasional wipe-down cleaning of sensor electrodes is the only maintenance that is normally required. When custom-sized for your tank, order a length longer than needed, then cut off the excess.

Use electrode spacers shown at right when incorporating multiple electrodes.

Choose the appropriate number and length of electrodes for your application. Remember, you can trim electrodes to size to custom fit your tank. Order a length that is longer than needed and cut off excess.

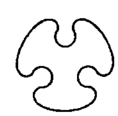
Removable Cut-to-Length Electrodes



316 Stainless Steel, Epoxy-Coated, light grey

Length	Part Number
12"	115267
24"	115394
36"	115395
48"	115396
60"	118694
72"	120458

Teflon® Electrode Spacers



	Part Number
For 3 Electrodes	113840
For 2 Electrodes	113835

Teflon is a registered trademark of Dupont Corp.

3rd ▶ Complete your Conductivity Level System with intrinsically safe HI-LO PAK™ switching units or an open controller board.

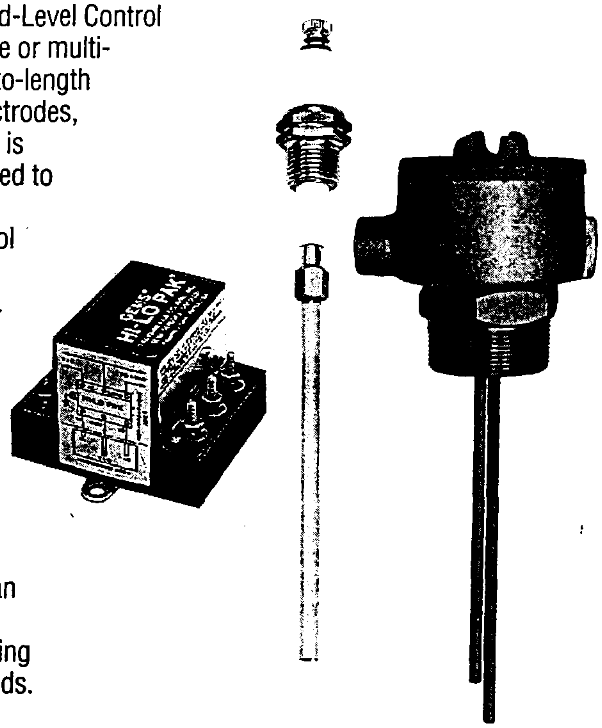
Order one HI-LO PAK relay for each sensor you're buying. You now have a rugged, dependable, intrinsically safe liquid level detection system.

The HI-LO PAKS may be used with sensors shown or any other standard, conductivity-type sensors. All units have a choice of sensitivity set points for the vast majority of requirements and are intrinsically safe.

It's As Simple As 1-2-3 to Use These Systems For Dependable, and Completely Automatic, Level Control for Electrically Conductive Liquids.

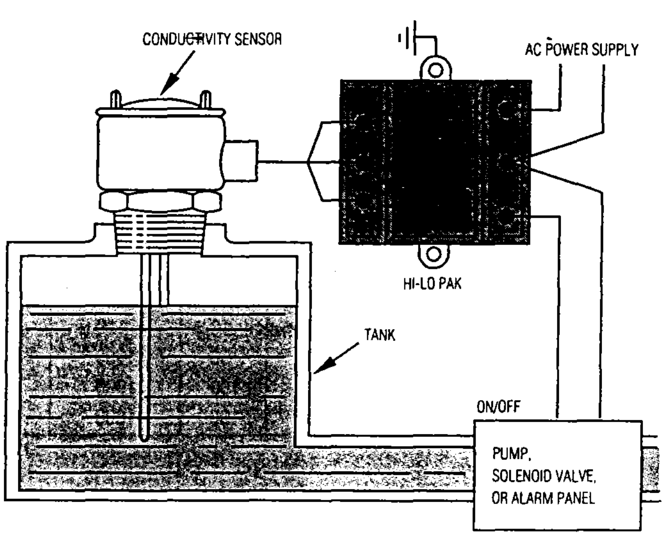
Conductivity Liquid-Level Control is SIMPLE and DIRECT... both in concept and operation. Utilizing low levels of electrical energy and the conductivity of the liquid itself, these solid-state systems provide consistently accurate "on/off" switching for an almost limitless range of liquid level control requirements.

Conductivity Liquid-Level Control consists of a single or multi-point sensor, cut-to-length stainless steel electrodes, and a controller. It is specifically designed to provide safe level sensing and control for electrically conductive liquids. In tank refill or pump-down applications, the controller automatically maintains liquid level high and low limits. The open board controller can be used for OEM applications involving non-explosive liquids.



How It Works

Differential level control shown below is typical. The COM. electrode extends to the lowest point in non-metallic tanks. In metal tanks the tank itself is the COM. electrode. Liquid level is automatically maintained between high and low limits by the controller with either PUMP-UP or PUMP-DOWN operation.

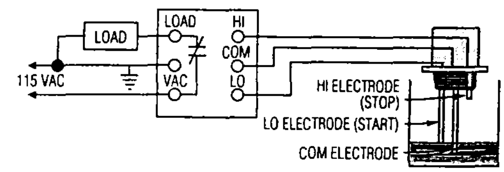


PUMP-UP Operation (for Normally Closed output).

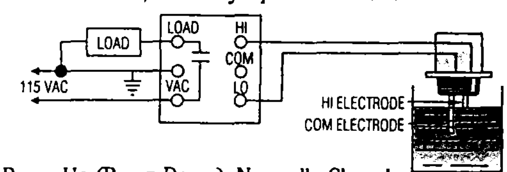
When falling liquid level uncovers the LO electrode, the controller output switches from N.O. to N.C. This turns the load "on" to activate a pump or solenoid valve and refill the tank. The load will remain "on" until the liquid reaches the HI electrode, switching the controller "off" and shutting down the pump or valve. The load will remain "off" until the LO electrode is again uncovered.

Typical Wiring Diagrams:

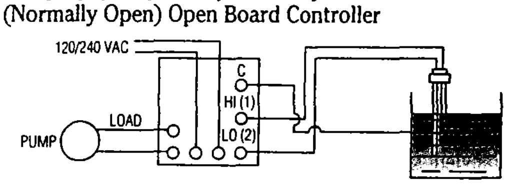
Pump-Up Control, Normally Closed HI-LO PAK



Hi Level Alarm, Normally Open HI-LO PAK



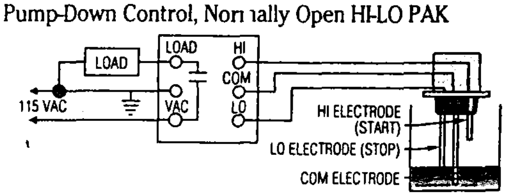
Pump-Up (Pump-Down), Normally Closed (Normally Open) Open Board Controller



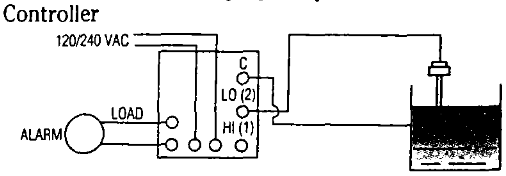
PUMP-DOWN Operation (for Normally Open output).

Operation is similar for PUMP-UP except that the N.O. controller load circuit is switched "on" when the liquid reaches the HI electrode, and "off" when the LO electrode is uncovered.

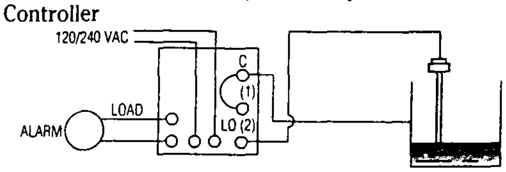
Pump-Down Control, Non ıally Open HI-LO PAK



Hi Level Alarm, Normally Open Open Board Controller

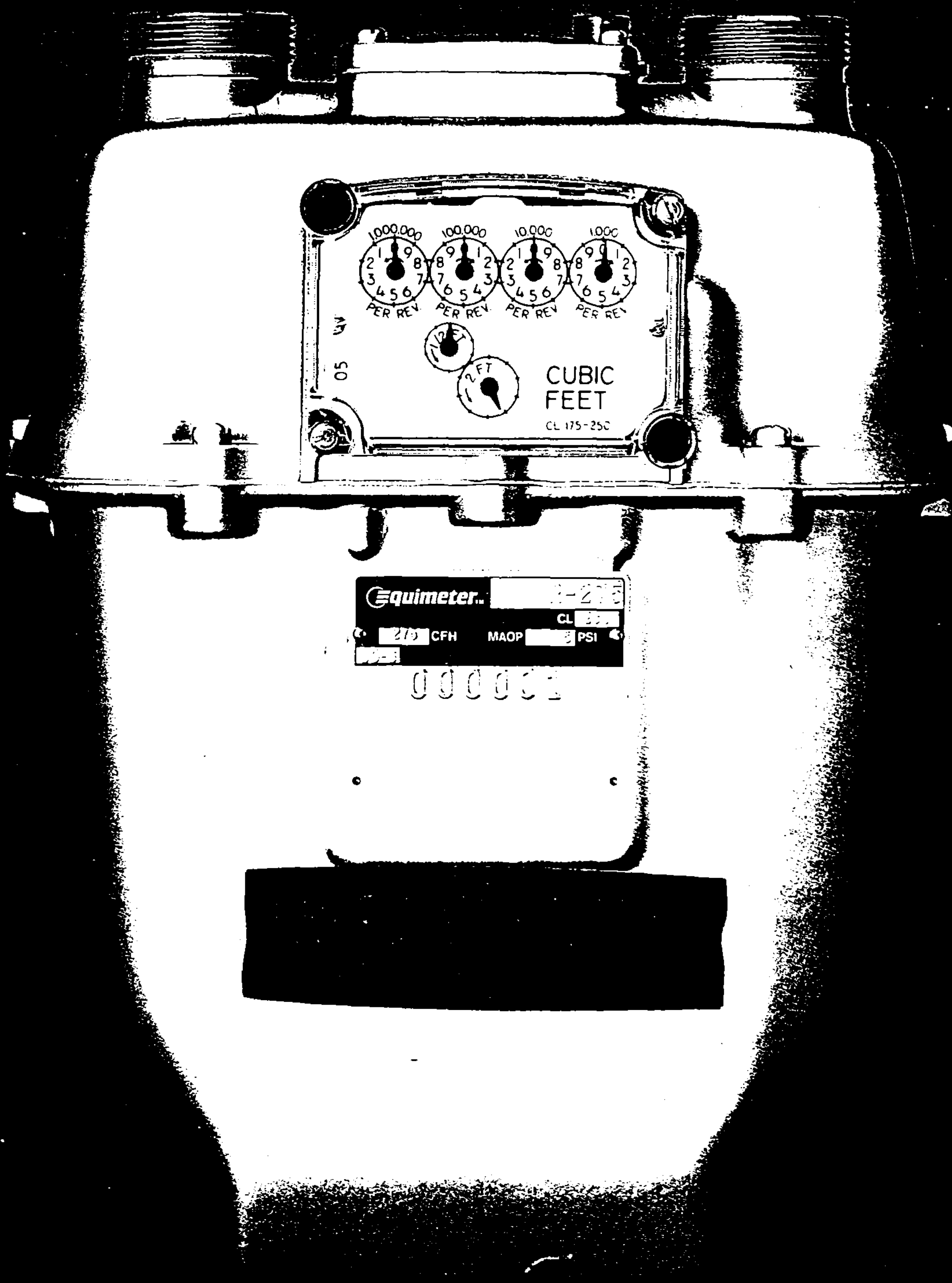


Low Level Alarm, Normally Closed Open Board Controller



M-1002
Rev. 6

Residential Gas Meters



Equimeter INCORPORATED

A BTR Company

Taking the Measure of Tomorrow

About Equimeter

Index

Ordering Information

When submitting orders or inquiries, please specify the following:

1. Size and type of meter (model number, standard or temperature compensated, etc.)
2. Kind of gas to be metered
3. Rate of flow to be metered – maximum SCFH
4. Maximum operating and test pressure
5. Ferrule size
6. Swivel specifications
7. Type of index
8. Special requirements (sealing, paint, accuracy spec., etc.)

Quality is a philosophy – an attitude at Equimeter Incorporated. We take pride in our craftsmanship; and through a team effort we construct top quality products for you.

Active Engineering and Research and Development Groups utilize state-of-the-art computer aided engineering and diagnostic equipment to design and produce gas metering products to meet the uncompromising demands of today's gas industry and enable you to adapt to the ever-changing needs of the future. This special balance of philosophy, attitude, dedicated workers and modern equipment assures you – our customer – that quality and performance have been skillfully designed into every product.

One visit to our advanced proving room will illustrate that every Equimeter gas metering product is inspected and proved accurate beyond any question. Rest assured that Equimeter products undergo more than an end-of-the-line inspection. Equimeter products are built with our reputation at stake; a reputation founded on years of experience, earned by the pride and skills of hundreds of dedicated professionals. And backed by sophisticated Quality Assurance instrumentation used at critical points throughout the manufacturing process.

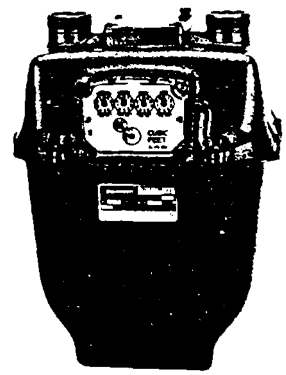
This is the residential gas meter proving room. In this room meters are individually calibrated to insure accuracy is within the tolerance demanded by you – our customer.

Single Joint Residential Gas Meters

Equimeter INCORPORATED
A BTR Company

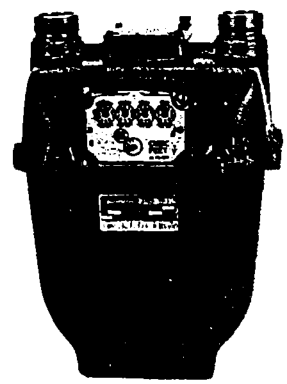
R-275
275 SCFH

These Class 250 residential meters are an improved revision of the R-200 family. The latest design concepts and modern engineering materials have been combined to provide a lighter weight, easier to handle, more durable meter which requires less maintenance and offers greater life expectancy.



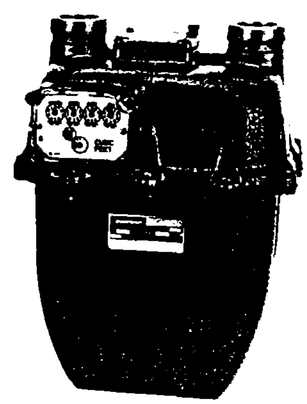
R-315
315 SCFH

These Class 250 residential meters are an improved revision of the R-200 family. The latest design concepts and modern engineering materials have been combined to provide a lighter weight, easier to handle, more durable meter which requires less maintenance and offers greater life expectancy.



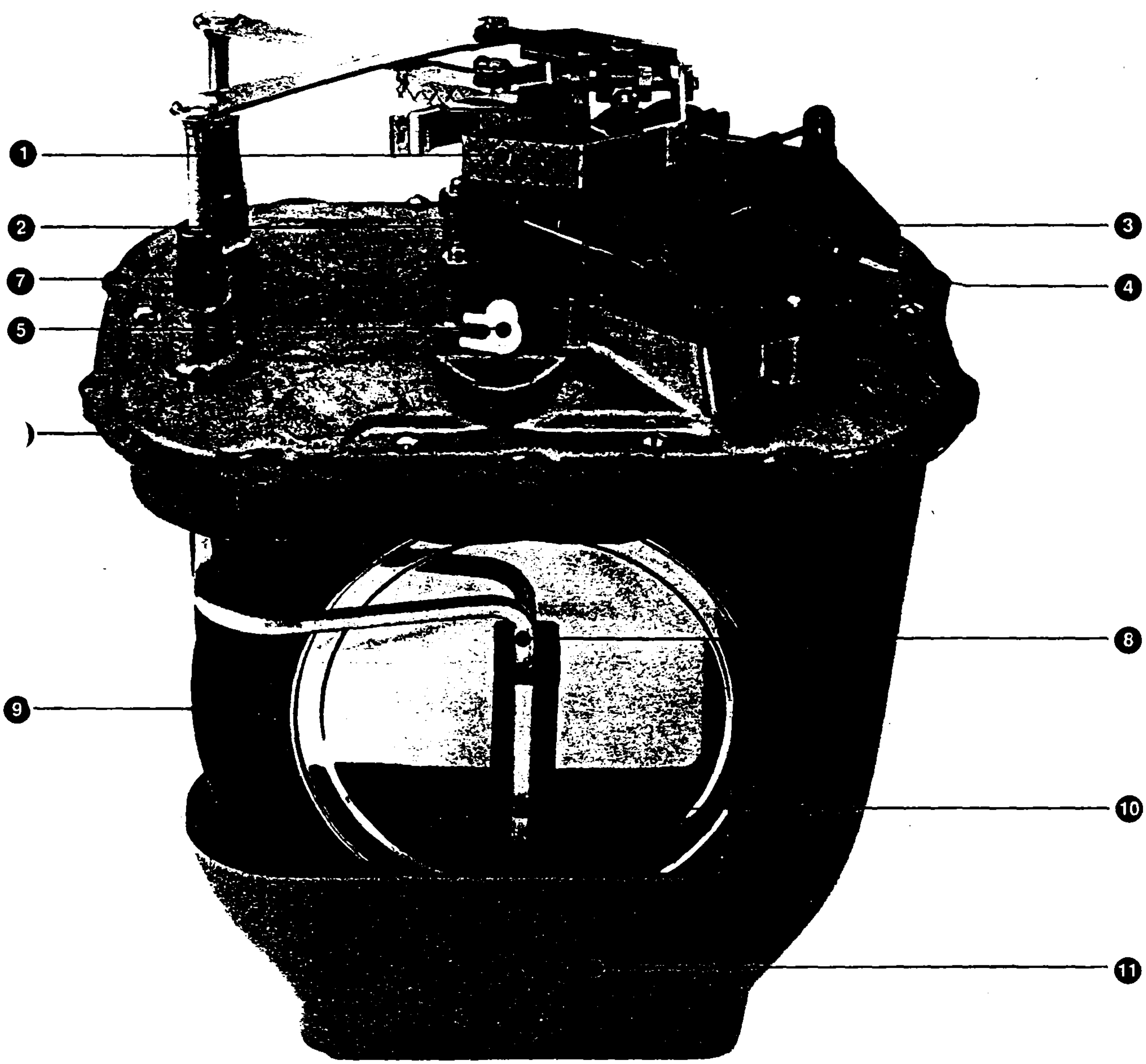
#415
415 SCFH

The Equimeter #415 continues to be the real workhorse in the Class 400 residential meter series. Its durable construction permits operation up to 2" W.C. differential to provide 900 CFH of 0.6 Sp. Gr. gas.



Note: All capacities are maximum, based on 0.6 Sp. Gr. gas measured at 4 oz. base pressure and 60°F at 1/2" W.C. differential pressure–in accordance with B109.1 specifications. Recommended meter operating temperature range: -30°F to + 150°F. See temperature compensation description page 8.

Features



Equimeter INCORPORATED
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1. **Temperature Compensation Element** – the improved design has increased strength to minimize deflection from valve drag. It is more rugged and linear in movement, thus, more accurate in compensation.

2. **Crank Bracket** – a simplified multi-purpose design incorporating internal valve guides and index shaft support. Fine tolerance, attained through precision molding, provides accurate positioning of the crank support. Low friction polymer eliminates need for lubrication.

3. **Valve Seat** – close tolerances achieved through molded phenolic construction minimize seat wear while providing a much smoother operation with a significantly lower differential. Incorporates easily installed external valve guides.

4. **Valve Cover and Links** – precision parts of engineered plastic materials reduce friction and are inert to chemicals and condensates commonly found in gas lines. Simple snap-on design with common left and right link reduces your parts inventory. This design reduces the job of valve replacement.

5. **Index Drive Shaft** – molded "dog" locks to brass index shaft eliminating "slop" often encountered in proving.

Gaskets are made of tough, resilient cork and neoprene composition and the linear amount of gasket is an absolute minimum due to "single-joint" design. This significantly reduces the chance of leakage.

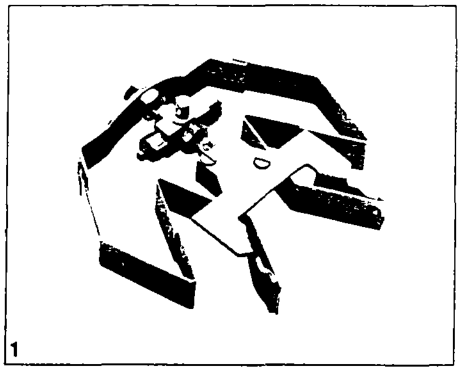
7. **Synthetic Rubber Glands** in the cover stuffing box and in the valve plate to seal the flag rods assure positive pressure sealing at these critical points. The gland design produces pressure integrity with a minimum amount of drag.

8. **One Piece Flag Rod** – closely controlled dimensions improve parallelism of all vertical segments. Greater distance between bearing points has been designed to provide lateral stability. Easy to position and install.

9. **Molded Port & Pan with integral dia-phragm stabilizers**–one piece construction, of glass fiber reinforced material, increases strength and eliminates a potential leak point. Integral stabilizers provide positive positioning of the diaphragm assembly.

10. **E-Clips** –plated steel clips install easily, facilitate repairs, and minimize parts inventory.

11. **Bodies and Covers** are of die-cast aluminum alloy to provide corrosion protection with minimum weight. Meters receive both prime and finish coats of paint to rovide additional protection and enhance terior appearances.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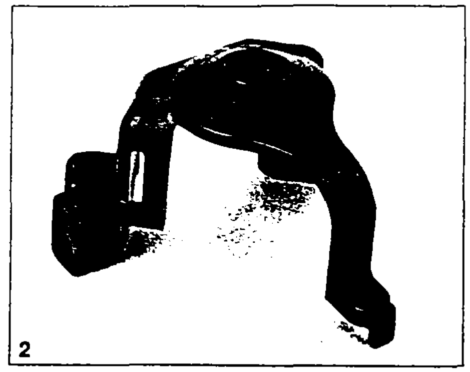
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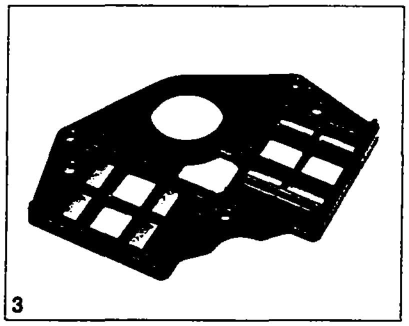
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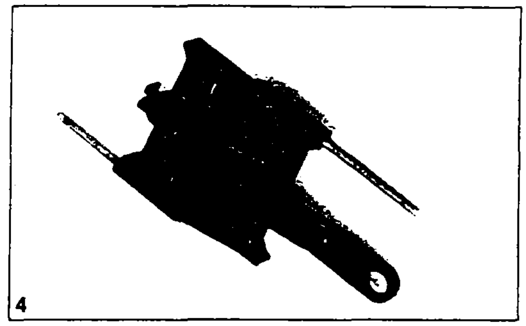
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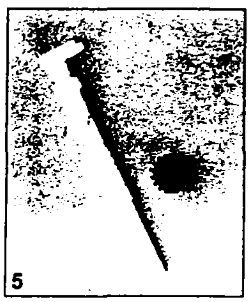
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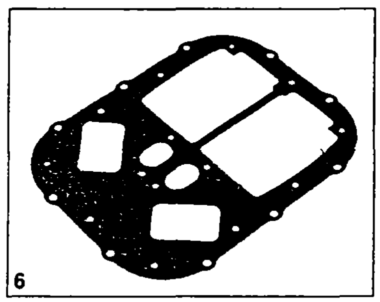
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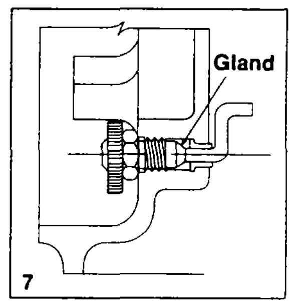

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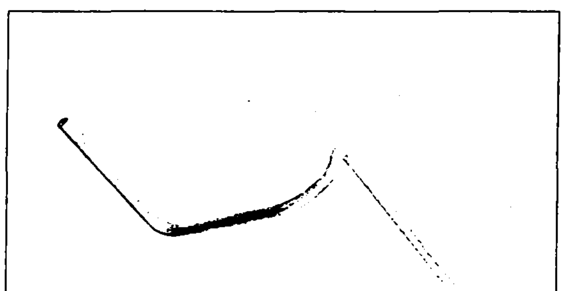
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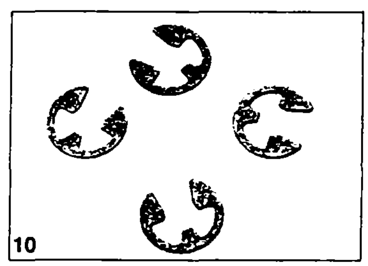
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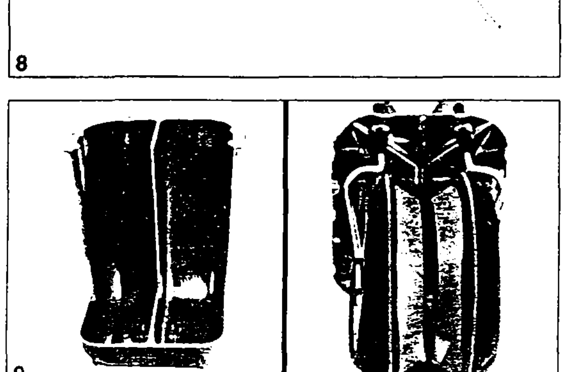
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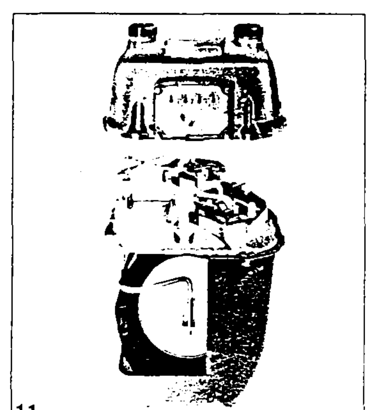

11

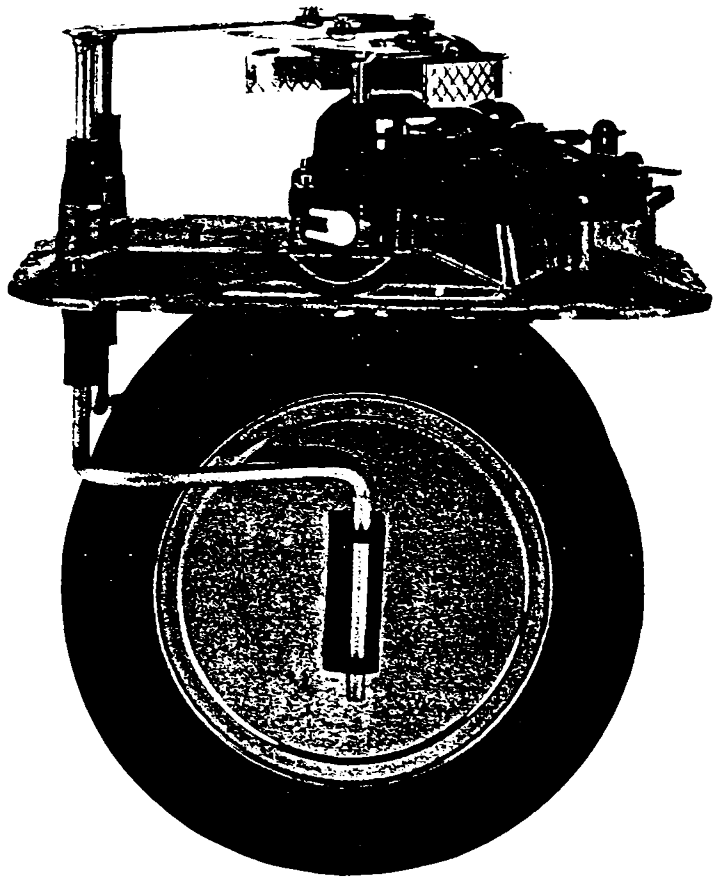
Module Replacement Program

Because of the "single joint" design of the Equimeter residential meter, easy replacement of all internal working parts is possible. A new measuring module can be installed simply by removing and replacing several screws.

Listed below are the modules available for our current line of residential meters. They are available in standard or temperature compensated construction and can be inserted into existing bodies and covers and calibrated in your shop.

This program is important in your long range planning. It means that the Equimeter meters you purchase today can be updated to new condition years from now at two-thirds or less of the cost of new meters.

Consider updating your meter population at a fraction of the cost of new meters. *For your immediate planning, many of the modules listed below fit into older Equimeter meters – those currently in your system that need attention now.*



Module Part Numbers

Meter Model	Standard	Temp. Compensated
S-200, R-200	001-63-502-54	001-63-502-55
S-275, R-275 R-315	001-63-502-06	001-63-502-07
MR-4, MR-6	001-63-502-22	001-63-502-23
MR-5, MR-8 MR-9	001-63-502-19	001-63-502-20
#415	001-41-502-70	001-41-502-71
MR-12	001-41-502-72	001-41-502-73

Equimeter INCORPORATED
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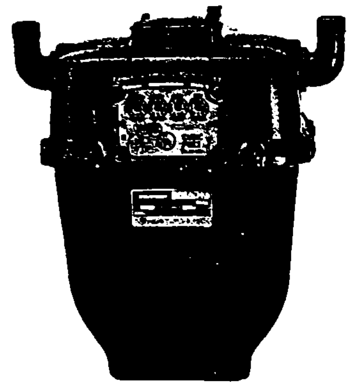
Many utility companies are replacing their tin meter population because of the high cost of skilled labor required to repair tin meters. Equimeter offers a complete line of residential meter replacements for the 5 Lt. and 10 Lt. tin meters, without any need for special connections or modifications to the meter set.

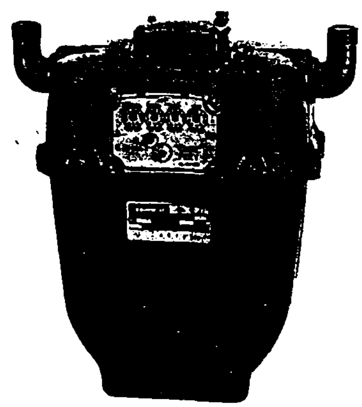
RT-230
210 SCFH

The RT-230 has 5 Lt. connections on 11 1/4" centers and makes use of the internal working parts of the R-275 residential meter.



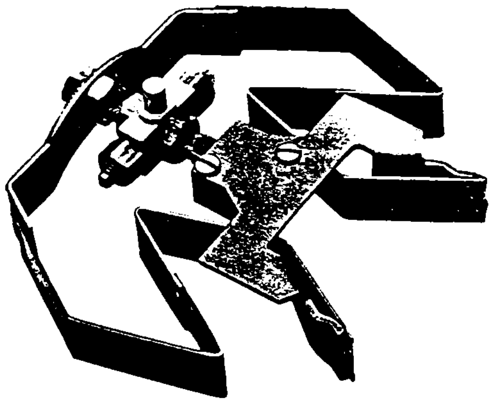
RT-275
250 SCFH

The same R-275 is converted to an RT-275 by fitting it with 10 Lt. connections of 11 1/4" centers.



Note: All capacities are maximum based on 0.6 Sp. Gr. gas measured at 4 oz. base pressure and 60°F at 1/2" W.C. differential pressure in accordance with B109.1 specifications. Recommended meter operating temperature range is -30°F to +150°F. See temperature compensation description on page 8.

Temperature Compensation



All Equimeter residential gas meters can be equipped with a bimetallic element that will automatically correct for changes in gas temperature and convert line volumes to the common base temperature of 60°F.

The fundamental difference in a temperature-compensated meter is the tangent. It features twin bimetallic elements as the active or compensating members. The tangent is mounted in such a way that temperature variations, causing expansion or contraction of the bimetallic element, alter the volume of gas displaced per revolution of the meter. This automatically causes the meter to speed up or slow down as required and does not affect valve timing.

Today, Equimeter's TC element is better than ever. It assures stable meter operation and accurate correction for gas temperature variations.

A temperature compensated meter can be outwardly identified by a difference in the manufacturer's badge color along with a "TC" notation on both the badge and the meter index. Standard meters have blue badges. TC meters have red manufacturer's badges.

The typical temperature compensation performance is within an accuracy band of ±2% over a flowing gas temperature range of -20°F to 120°F.

Test Meters

Equimeter Test Meters are applicable where minute quantities of gas must be measured with a high degree of accuracy. They are used in factories, showrooms, laboratories and various testing departments. Some utilities use them to demonstrate to customers the amount of gas consumed by ranges, furnaces, clothes dryers and other gas appliances.

One of the more popular uses of the smaller test meter has been in the area of pollution control. The Environmental Protection Agency has set standards of performance for limiting gaseous and particulate emissions from factories. Federal, state and local pollution control authorities have discovered a need for dependable precision instruments to sample and evaluate pollutants. Equimeter Test Meters are being used extensively in stack sampling and pollution monitoring devices.

Operation

All Equimeter Test Meters are equipped with a special test index. This test index has a sweep hand which can be compared to the sweep hand on a stopwatch. Minute amounts of flow are precisely measured on the finely graduated sweep hand circle. Timing of the sweep hand accurately determines small flow rates.

Test Meter Models Available

Model	Capacity-SCFH of 0.6 Sp. Gr. gas @ 1/2" w.c. diff.
S-275	250
R-275	275
R-315	315
#415	415

Note: Capacity ratings based on connections as per ANSI B-109.1.

Equimeter Series for Meter Reading Technology

Equimeter INCORPORATED
A BTR Company

TouchRead® Automated Meter Reading & Billing System

TouchRead® Automated Meter Reading & Billing System

Equimeter's TouchRead Automated Meter Reading and Billing System helps increase reading speed, virtually eliminates callbacks and reduces reading and billing errors. TouchRead System-equipped meters are read by touching the tip of a reading gun to a remote or meter-mounted TouchPad and pressing a button on the gun's handle. The meter is instantly read, and its data is electronically transferred to a Solid State Electronic Route Book carried by the meter reader.

Electronic Communications Index

Each Equimeter Electronic Communications Index contains an electronic chip for transmitting meter reading data to a remote TouchPad which, in turn, transfers it to a TouchRead System reading gun, on command. A built-in index enables the index to be read visually, if required.

Indexes are available for aluminum case residential meters through Class 400. They can be factory installed or retrofitted in the field. They are available for Equimeter residential meters and competitive meters with adapter assemblies.

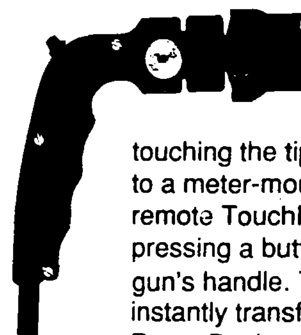
Indexes are fully compatible with centralized automatic meter reading, for installation today or for future conversions.

Solid State Electronic Route Book

This device accepts electronic data entry from TouchRead System-equipped meters. It can also be instantly switched to a manual reading mode, for accepting visual readings entered through its built-in key-pad. These devices can be easily programmed to store route information, meter account information, meter reader prompts and questions or alerts about individual accounts.

TouchRead System Reading Gun

Designed for use with Solid State Electronic Route Books, TouchRead System electronic meter reading guns are lightweight and easy to use.



Meter reading data is obtained by touching the tip of the gun to a meter-mounted or remote TouchPad and pressing a button on the gun's handle. The data is instantly transferred to the Route Book carried by the meter reader. TouchRead System electronic meter reading guns help eliminate visual meter readings, and, when properly used with TouchRead System equipment, they increase meter reading speed and virtually eliminate reading errors, compared to manual direct-read methods.

TouchRead equipped meters *can be electronically interrogated by other hand-held computer systems available today. Minor modifications are required to existing hand-held systems.*

AutoRead™ Centralized Automatic Meter Reading

Automatic Meter Reading (AMR) from Equimeter is a telephone-based, call-outbound system, for utility control and reliable, low-cost meter reading. The Equimeter Meter Interface Unit responds to calls initiated through AMR software installed on an IBM-PC at your office, either automatically, for routing reading, or on demand, for final reads or usage monitoring. It works without batteries or interfering with the customer's phone usage.

A simple three-wire hook-up of an Equimeter Electronic Communications Index provides input from Equimeter and other residential meters to the Equimeter Meter Interface Unit (MIU). Access to the MIU is obtained through telephone company central office equipment.

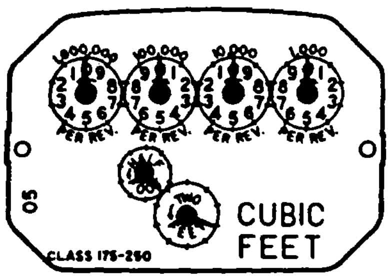
The future for today and tomorrow.

Management Reporting and Billing

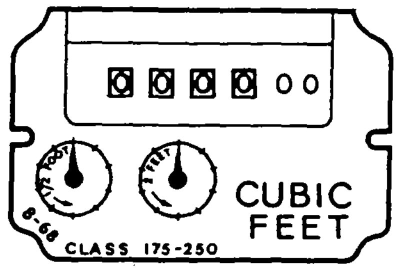
Equimeter's TouchRead System automates the billing and management report preparation processes using software designed for IBM-PC computers. Depending on the utility's requirements, billing and management reporting software is available for use with a stand-alone PC and printer, or for interfacing with a mainframe computer.

For more information on Equimeter's TouchRead and AutoRead systems see Bulletin M-1007

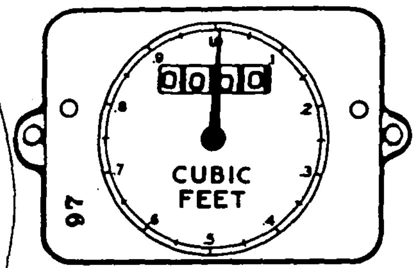
Residential Gas Meter Indexes



Standard Circular Reading Plastic



Standard Direct Reading Plastic



Test Meter Index

Index Assemblies

Type	S-275, R-275, R-315			#415			Dial
	Index Assembly with Drive Gear Part Number	Number of Teeth: Index Drive Gear	Number of Teeth: Stuffing Box Gear	Index Assembly with Drive Gear Part Number	Number of Teeth: Index Drive Gear	Number of Teeth: Stuffing Box Gear	
Plastic Circular Reading	001-63-538-03	12	24	–	–	–	3 Circle
	001-63-538-05	11	11	001-41-538-05	18	18	4 Circle
	001-63-538-10	11	11	001-41-538-10	18	18	4 Circle
	001-63-538-11	11	11	001-41-538-11	18	18	4 Circle
	001-63-538-15	11	11	001-41-538-15	18	18	4 Circle
				001-41-538-25	18	18	4 Circle
Plastic Direct Reading	001-63-538-62	11	11	001-41-538-62	18	18	5 Wheel
	001-63-538-63	11	11	001-41-538-63	18	18	5 Wheel
	001-63-538-68	11	11	001-41-538-68	18	18	4 Wheel
	001-63-538-69	11	11	001-41-538-69	18	18	4 Wheel
	001-63-538-66	12	24	001-41-538-66	12	24	4 Wheel
	001-63-538-70	11	11	001-41-538-70	18	18	4 Wheel
	001-63-538-64	16	16	001-41-538-64	16	16	6 Wheel
Test Indexes	001-63-537-83	16	20	001-41-537-83	13	20	4 Wheel
	001-63-538-93	12	30	001-41-538-93	22	10	4 Wheel
	001-63-537-97	12	24	001-63-537-97	12	24	4 Wheel

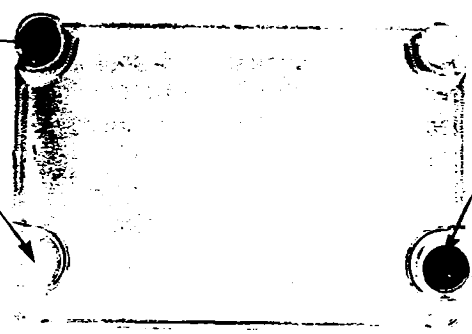
Rockseal "Tamper Obvious" Devices

Equimeter INCORPORATED
A BTR Company

Devices-Rockseal Index Box

Rockseal index box screws, Fil. Hd. Stl. Mach. Screw (10-24 x 11/16") Part Number 950525

The Lexan® Rockseal index box has molded recesses at the upper left and lower right corners into which molded plastic plugs are inserted to cover index box mounting screw heads.



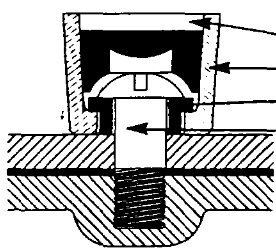
Rockseal plug 001-63-056-05 packaged either 100 or 1000 pieces per package.

Kit consisting of:
1 index box
2 Rockseal plugs
4 screws
- 001-63-656-50 with drains
- 001-63-656-51 without drains

Front View
Part Number 001-63-006-05 With Drains
001-63-006-06 Without Drains
Equimeter Lexan® Index Box

Lexan is a registered trademark of General Electric Corporation.

Rockseal Handhole Plate Device-Cross Section



Rockseal Plug 001-63-056-05
Handhole Plate Seal Cup 001-63-057-02
Handhole Plate Seal Spacer 001-63-053-01
Handhole Plate Mounting Screw (#10-24 x 11/16") 950532
Handhole Plate 001-60-004-00
Handhole Plate Gasket 001-63-160-50
Meter Cover Casting

Kit consisting of Rockseal plug, seal cup, seal spacer and mounting screw is part number 001-63-656-00. Components packaged individually in lots of 100 pieces per package.

Index Assemblies

	S-275, R-275, R-315	#415				
Type	**Index Assembly with Drive Gear Part Number**	**Index Assembly with Drive Gear Part Number**	**Legend**	**First Reading Circle**	**Proving Hand**	**Description**
Plastic Circular Reading	001-63-538-03	–	Cu. Ft.	1000	1'	Standard-C.C.W.
	001-63-538-05	001-41-538-05	Cu. Ft.	1000	2' 1/2"	Standard-C.C.W.
	001-63-538-10	001-41-538-10	Cu. Ft.	1000	2'	Standard-C.C.W.
	001-63-538-11	001-41-538-11	Cu. Ft.	1000	2'	Temp. Comp.-C.C.W.
	001-63-538-15	001-41-538-15	Cu. Ft.	1000	2' 1/2"	Temp. Comp.-C.C.W.
		001-41-538-25	Cu. Ft.	1000	2' 1/2"	415 on Dial
Plastic Direct Reading	001-63-538-62	001-41-538-62	Cu. Ft.	10	2' 1/2"	Standard
	001-63-538-63	001-41-538-63	Cu. Ft.	10	2' 1/2"	Temp. Comp.
	001-63-538-68	001-41-538-68	Cu. Ft.	100	2' 1/2"	Standard
	001-63-538-69	001-41-538-69	Cu. Ft.	100	2' 1/2"	Temp. Comp.
	001-63-538-66	001-41-538-66	Cu. Ft.	100	1'	Standard
	001-63-538-70	001-41-538-70	Cu. Ft.	100	2'	Standard
	001-63-538-64	001-41-538-64	Cu. Meters	$0.1M^3$	$0.05M^3$	Fully Metric
Test Indexes	001-63-537-83	001-41-537-83	Cu. Ft.	1/10	1/10'	Test Index
	001-63-538-93	001-41-538-93	Cu. Meters	$.01M^3$	$.01M^3$	Fully Metric Meter Test
	001-63-537-97	001-41-537-97	Cu. Ft.	1	1'	Test Index

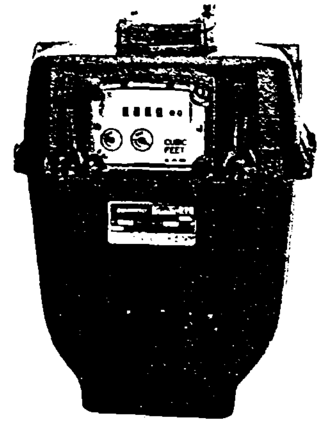
Special Service

Liquified Petroleum Gas Metering (LPG)

The Equimeter S-275 was designed especially for the LPG industry. The S-275 has been tested and proven for all services, and can particularly measure LP gases from bottle sets, bulk storage and distribution systems to the house.

Manufactured under the same exacting Quality Control requirements as Equimeter's residential gas meters, the S-275 contains the same joint design and utilizes the same corrosion resistant materials that exhibit high lubricity for low differential operation. The major difference is the connections. The S-275 is available with 3/4" FPT connections. The "S" denotes side-connection.

(All Equimeter residential meters described in this brochure can be used to measure liquified petroleum gases. Specifications for these meters and capacities when used on LPG are given on page 15.)



Industrial Gas Measurement

Industry today is placing a tremendous amount of emphasis on fuel conservation and fuel allocation within its facilities. Plant accountants making efforts to keep increasingly accurate records of fuel gas consumption as well as consumption of various special process gases within their facilities. Equimeter's complete line of single joint diaphragm meters provides industry with the specialized metering equipment they need to do the job and to do it accurately. Listed below are some of the special type service gases used by industry that Equimeter meters are capable of handling. See your local Equimeter representative or distributor for further information regarding in-plant metering and special gas services.

Gas			
Air		Krypton	Kr_2
Argon	A_2	Methane	CH_4
Butane	C_4H_{10}	Nitrogen	N_2
* Carbon Dioxide	CO_2	Neon	Ne
* Carbon Monoxide	CO	Pentane	C_5H_{12}
Ethane	C_2H_6	Propane	C_3H_8
† Helium	He_2	Xenon	Xe_2
† Hydrogen	H_2		

* Gas must be 100% dry.

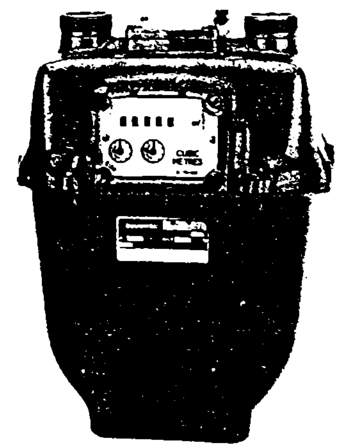
† Because of the low density of these gases, meters for this sevice may not be used in excess of 50% of their pressure rating.

Metric Meters

As the United States and the gas industry gradually convert to the metric system, Equimeter is ready to help. For bell provers calibrated with metric scales, meters must be equipped with a metric output (50 liters). It is also necessary that the meters have some number of full revolutions of the tangent assembly for that given metric output. Listed–and now available from Equimeter–are current meter models along with their metric counterparts with metric outputs.

Also, to assist you is a table of metric conversion factors. For further information about Equimeter metric meters, consult your local Equimeter representative.

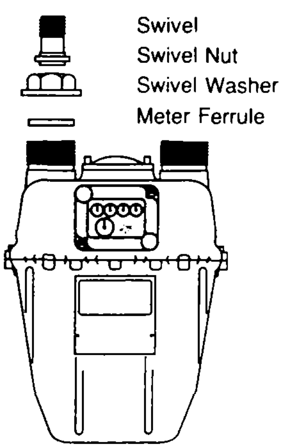
Cubic Foot Models	Metric Models	Capacity M^3/hr.
S-275	MR-5	7
R-275	MR-8	8
R-315	MR-9	9
#415	MR-12	12



Std. Meters^3/Hr. x 35.31 = Std. Ft.^{3}/Hr. (SCFH) Std. Ft.^{3}/Hr. (SCFH) x 0.0283 = Std. Meters^3/Hr.	Kilo Pascals (KPa) x 0.145 = psi psi x 6.90 = Kilo Pascals (KPa)	millimeters water (mm H_2O) x 0.039 = in. w.c. in. w.c. x 25.4 = millimeters water (mm H_2O)
Kilograms/centimeter^2 (Kg/cm^2) x 14.22 = psi psi x 0.0703 = Kilograms/centimeter^2 (Kg/cm^2)	Bars x 14.50 = psi psi x .0689 = Bars	millimeters mercury (mm Hg) x 1.868 = in. w.c. in. w.c. x 0.535 = millimeters mercury (mm Hg)

Meter Connections

Equimeter offers a complete line of meter connections to meet your installation needs. Listed below are some of the more common swivel nut and swivel washer sizes available. Common swivels in standard and insulated varieties can be found on page 14. Black iron or galvanized connections are available. For sizes other than those listed, contact your local Equimeter representative.



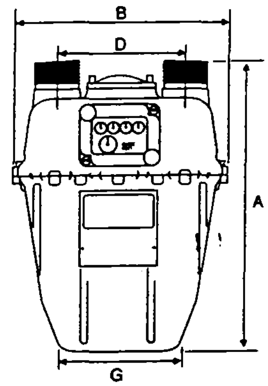
Ferrule Size	Swivel Washers Part Number	Swivel Nuts: Galvanized Part Number	Swivel Nuts: Black Iron Part Number
1 ¼"	001-61-153-02	001-61-165-07	001-41-165-07
10 Lt.	003-51-131-04	003-51-130-00	003-51-230-00
20 Lt.	001-61-154-02	001-61-166-00	001-41-166-00
30 Lt.	001-61-155-03	001-61-167-07	001-41-167-07
45 Lt.	001-62-156-02	001-62-168-00	001-41-168-00
1A Spg.	001-61-153-02	001-61-165-16	001-41-165-16
2 Spg.	001-62-156-03	001-41-130-00	001-41-230-00
3 Spg.	011-14-131-01	001-64-167-02	001-64-168-02

Swivels

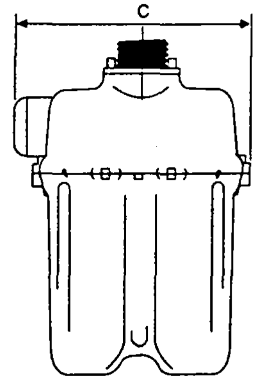
Meter Ferrule Size	Straight or Offset	Galvanized Part No.	Black Iron Part No.	Pipe Size	Amount of Offset	Height	Insulating *Yes /No	Galvanized Swivel Set Part No.	Black Iron Swivel Set Part No.
1-1/4"	S	001-61-165-08	001-41-165-08	1"		2 7/32"	No	001-61-365-08	001-41-365-08
	O	001-61-165-27		1/2"	2 3/4"	3 5/16"	No	001-61-365-27	
	S	001-61-165-58		1"		2 7/32"	Yes	001-61-365-58	
	O	001-61-165-26	001-41-165-26	3/4"	1"	2 11/16"	No	001-61-365-26	001-41-365-26
	S	001-61-165-02		3/4"		2 3/8"	No	001-61-365-02	
	S	001-61-165-52		3/4"		2 3/8"	Yes	001-61-365-52	
	O	001-61-165-55		3/4"	2 11/16"	2 15/16"	Yes	001-61-365-55	
	O	001-61-165-05		3/4"	2 11/16"	2 15/16"	No	001-61-365-05	
	O	001-61-165-76		3/4"	1"	2 11/16"	Yes	001-61-365-76	
10 Lt.	S	003-51-134-00		3/4"		2 5/16"	No	003-51-334-00	
	S	003-51-134-50		3/4"		2 6/16"	Yes	003-51-334-50	
	O		003-51-236-50	3/4"	1"	3 1/4"	Yes		003-51-436-50
20 Lt.	S	001-61-165-11	001-41-165-11	1"		2 3/4"	No	001-61-365-11	001-41-365-11
	O	001-61-166-03		1"	1 5/8"	3 1/2"	No	001-61-366-03	
	S	001-61-166-15		3/4"		2 3/8"	No	001-61-366-15	
	O	001-62-168-11		3/4"	3 3/16"	3 13/16"	No	001-62-368-11	
	S	001-61-166-02		1"		3 3/4"	No	001-61-366-02	
	O	001-61-166-13		1/2"	2 11/16"	3 7/16"	No	001-61-366-13	
	S	001-61-165-61	001-41-165-61	1"		2 3/4"	Yes	001-61-365-61	001-41-365-61
	S	001-61-166-65		3/4"		2 3/8"	Yes	001-61-366-65	
	S	001-61-165-61	001-41-165-61	1"		2 3/4"	Yes	001-61-565-61	001-41-565-61
	S	001-61-166-52		1"		3 3/4"	Yes	001-61-366-52	
	S	001-61-166-15		3/4"		2 3/8"	No	001-61-566-15	
	O	001-61-166-63		1/2"	2 11/16"	3 7/16"	Yes	001-61-366-63	
	S	001-61-165-61		1"		2 3/4"	Yes	001-61-665-61	
30 Lt.	S	001-61-167-02	001-41-167-02	1 1/4"		2 7/8"	No	001-61-367-02	001-41-367-02
	S	001-61-167-52	001-41-167-52	1 1/4"		2 7/8"	Yes	001-61-367-52	001-41-367-52
	S	001-61-165-62	001-41-165-62	1"		2 27/32"	Yes	001-61-365-62	001-41-365-62
	S	001-61-165-12	001-41-165-12	1"		2 27/32"	No	001-61-365-12	001-41-365-12
	S	001-61-165-62	001-41-165-62	1"		2 27/32"	Yes	001-61-565-62	001-41-565-62
	S	001-61-167-52	001-41-167-52	1 1/4"		2 7/8"	Yes	001-61-467-52	001-41-567-52
45 Lt.	S	001-62-168-02	001-41-168-02	1 1/4"		3 7/8"	No	001-62-368-02	001-41-368-02
	O	001-62-168-03		1 1/4"	1 5/8"	3 7/8"	No	001-62-368-03	
	S	001-62-168-52	001-41-168-52	1 1/4"		3 7/8"	Yes	001-62-368-52	001-41-368-52
	O		001-41-168-56	1 1/2"	1 1/8"	4 1/16"	Yes		001-41-368-56
	S	001-62-168-04	001-41-168-04	1 1/2"		3"	No	001-62-368-04	001-41-368-04
	S	001-62-168-54	001-41-168-54	1 1/2"		3"	Yes	001-62-368-54	001-41-368-54
	S	001-62-168-52		1 1/4"		3 7/8"	Yes	001-62-468-52	
	S	001-62-168-54		1 1/4"		3"	Yes	001-62-468-54	
#2 Spg.	S	001-62-168-21	001-41-168-21	1 1/4"		3 1/8"	No	001-62-368-21	001-41-368-21
#3 Spg.	S	011-14-134-04		1 1/2"		3 1/16"	No	011-14-334-04	

*** The minimum insulation breakdown voltage for insulating swivels (Assembled Joint) is 2500 volts.**

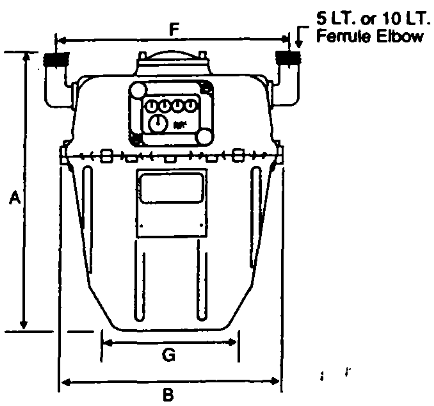
Dimensions



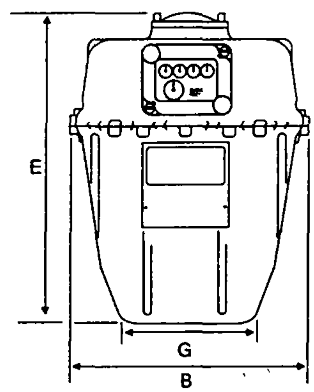
R-275, R-315, #415



Side View – All



RT-Meter



S-275

Meter Model	A	B	C	D	E	F	G
S-275		10 1/8"	8 1/2"	–	13 1/4"	–	5 1/4"
R-275*	13 23/64"	10 1/8"	8 1/2"	6"	–	–	5 1/4"
R-315*	13 23/64"	10 1/8"	8 1/2"	7"	–	–	5 1/4"
#415*	14 37/64"	11 1/8"	9 3/8"	7" or 8 1/4"	–	–	6"
RT-230	13 5/8"	10 1/8"	8 1/2"	–	–	11 1/4"	5 1/4"
RT-275	13 5/8"	10 1/8"	8 1/2"	–	–	11 1/4"	5 1/4"

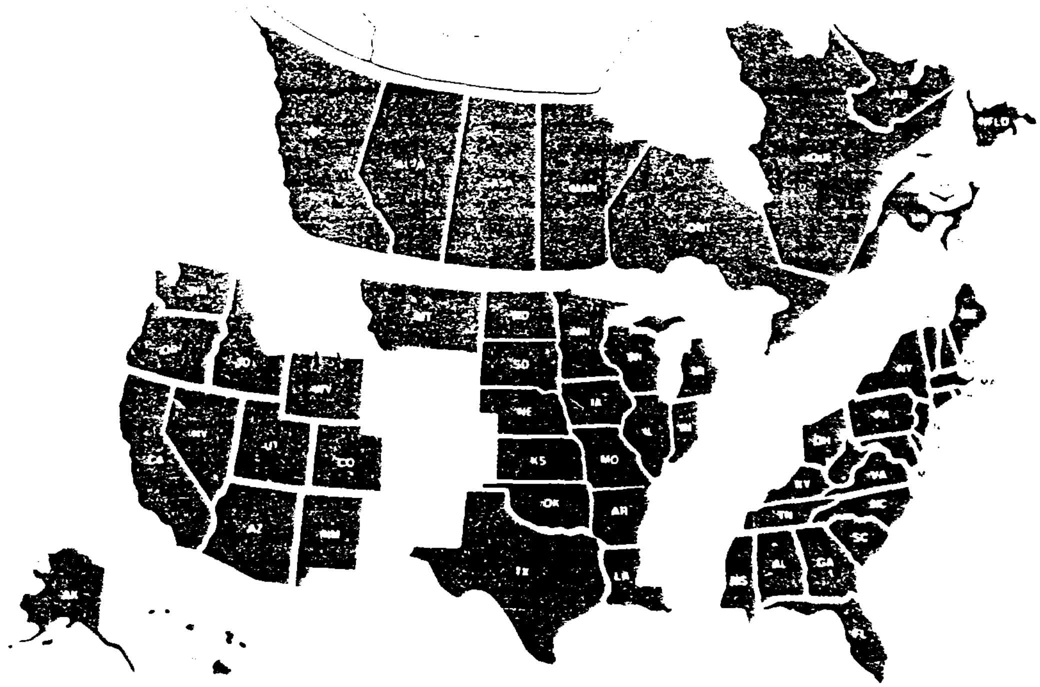
* "A" dimension assumes 20 Lt. connections. "A" varies slightly for other connections.

Specifications

Meter Model	Capacity-SCFH 1/2" W.C. Diff. Nat.	But.	Prop.	Air	Max. W.P. PSI	Approx. Shpg. Wt. Lbs.	No. of Rev. per Ft³	Stuff. Box Shaft Ft³/Rev.	Meter Connections Available
R-275*	275	150	175	215	5-10	14	8	2	10, 20, 30 Lt., 1 1/4", 1A SPG, #2 SPG.
R-315*	315	170	200	245	5-10	14	8	2	20, 30, 45 Lt., 1 1/4", 1A SPG, #2 SPG.
#415†	415	225	260	320	10-25	21	6.5	2	20, 30, 45 Lt., 1 1/4", 1A SPG., #2 SPG., #3 SPG.
S-275	250	150	175	195	5-10	14	8	2	3/4" NPT
RT-230	210				5	14	8	2	5 Lt.
RT-275	250				5	14	8	2	10 Lt.

*Capacity ratings based on 20 Lt. connections per ANSI B-109-1.
†Capacity ratings based on 30 Lt. connections per ANSI B-109-1.

SALES OFFICES—UNITED STATES, CANADA AND INTERNATIONAL



WESTERN REGION | MID-CONTINENT REGION | EASTERN REGION

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Suite 211
Houston, Texas 77069
Telephone (713) 893-4888
FAX (713) 893-4334

EASTERN REGION
400 North Lexington Avenue
Pittsburgh, PA 15208
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FAX (814) 375-8449

Equimeter INCORPORATED

Equimeter Incorporated
805 Liberty Boulevard
DuBois, Pennsylvania 15801

A BTR Company

Authorized Distributor:

WARRANTY: Equimeter Incorporated (Equimeter) warrants its products only against defects in materials and workmanship. Equimeter's liability and customer's exclusive remedy under this warranty or any warranty extends for a period of one (1) year from the date of Equimeter's shipment and is expressly limited to repayment of the purchase price, repair, or replacement, at Equimeter's option, during said period, upon proof satisfactory to Equimeter and upon customer's returning and prepaying all charges on such products to factory or warehouse designated by Equimeter. THIS WARRANTY IS MADE EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, EXPRESS, IMPLIED, OR STATUTORY, WITH RESPECT TO QUALITY, MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.

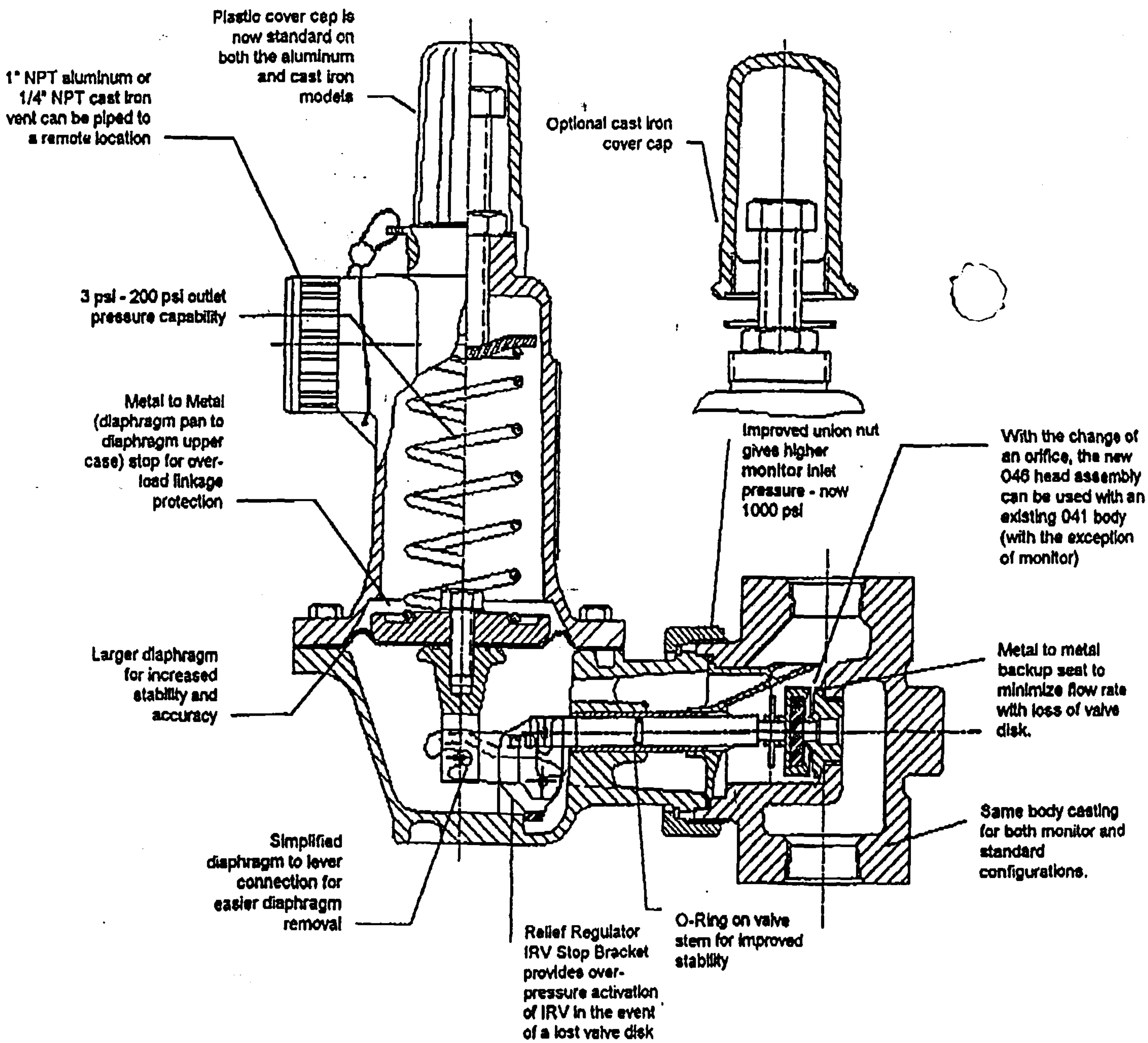
Equimeter INCORPORATED

RDS-1312

046 Field Regulator Design Improvements

New Configurations
*Aluminum Pilot Loaded
*Aluminum Monitor
*Aluminum Monitor with IRV

*An optional IRV provides improved relief and corrosion protection



All aluminum case units have the same inlet and outlet pressure capability as cast iron case units, and are available with internal relief, internal relief monitor and pressure loaded.

Equimeter INCORPORATED

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Regulator Installation and Maintenance Instructions, and Parts List

046 Field Regulators

Simple design, rugged construction and top performance make these regulators a dependable, economical answer for a wide variety of pounds to pounds applications. They are also available with an internal relief valve (IRV) and with a stem seal and control line tap for use as the upstream regulator in a monitor set.

The 046 Regulators are typically used for farm taps, field regulator applications, propane tanks and high pressure industrial air or gas uses.

Maximum Inlet Pressure

046, 046-M, 046C & 046CM Models

Orifice	SPRINGS Yellow	Aluminum, White Tan, Dark Green	Gray
1/8"	500 psi	1000 psi	1000 psi
3/16"	500 psi	1000 psi	1000 psi
1/4"	500 psi	500 psi	500 psi
5/16"	300 psi	400 psi	400 psi
3/8"	300 psi	300 psi	400 psi
1/2"	100 psi	100 psi	100 psi

Inlet Pressures .... to 1000 psi
Outlet Pressures .... 3 to 200 psi
Pipe Sizes .... ¾", 1", and 1¼"

Maximum Inlet Pressure 046-2 and 046-2M Models

Orifice	SPRINGS Yellow	Aluminum, White, Tan, Dark Green
1/8"	500 psi	925 psi
3/16"	500 psi	925 psi
1/4"	500 psi	500 psi
5/16"	300 psi	400 psi
3/8"	300 psi	300 psi
1/2"	100 psi	100 psi

Inlet Pressures .... to 925 psi
Outlet Pressures .... 3 to 125 psi
Pipe Sizes .... ¾", 1", and 1¼"

Maximum Inlet Pressure 046-PL and 046-CPL Models

Orifice	SPRINGS Yellow	Aluminum
1/8" to 1/2"	250 psi	250 psi

Inlet Pressures .... to 250 psi
Outlet Pressures .... 5 to 100 psi
Pipe Sizes .... ¾", 1", and 1¼"

Valve Material	Max Inlet Pressure	Max Diff. Pressure
Poly-U Tan (90) duro	1000 psig	800 psig
Buna-N (80 duro)	525 psig	400 psig
Viton (70 duro)	525 psig	400 psig

Installation and Start-Up

1. Remove the shipping plugs from both the regulator inlet and outlet connections.
2. Make certain that the inside of the piping and the regulator inlet and outlet connections are clean—they must be free of dirt, pipe dope and other debris.
3. Use pipe joint material only on the male threads of the pipe being connected to the regulator. *Do not* use pipe joint material on the female threads of the regulator.
4. Install the regulator in the line. Make certain that the gas flow through the regulator is in the direction indicated by the arrow on the regulator body.

The regulator may be installed in any position: right side up, up side down, vertical piping, diagonal piping, etc. If required, the diaphragm case may be rotated 360° in any number of increments. To rotate diaphragm case assembly to another position in relation to the body loosen coupling nut (33). Make certain it is retightened to 35 to 50 Ft.-Lb. to hold diaphragm case assembly in new position and to reseal.

The diaphragm case vent must be positioned to protect against flooding, drain water, ice formation, traffic, tampering, etc. The vent must be protected against nest building animals, bees, insects, etc. to prevent vent blockage and to minimize the chances of foreign material collecting in the vent side of the regulator diaphragm.

CAUTION

Turn gas on very slowly. If an outlet stop valve is used, it should be opened first. Do not overload the diaphragm with a sudden surge of inlet pressure. Monitor the outlet pressure during start-up to prevent an outlet pressure overload.

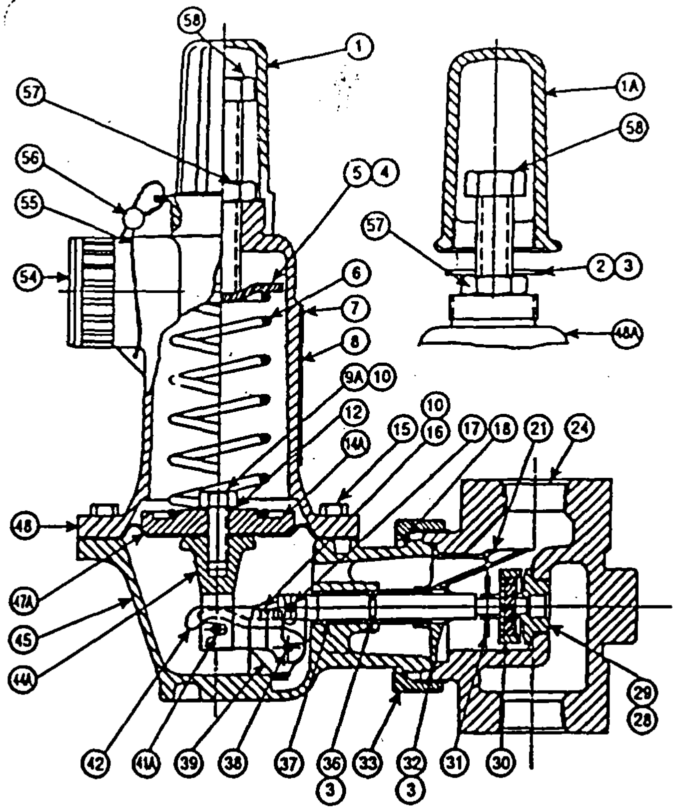
5. Turn gas on very slowly.
6. Make certain that there are no leaks and that all connections are tight.
7. Adjust set-point (outlet pressure) by turning adjustment screw (58). Turn clockwise to increase and counterclockwise to decrease. Be sure to tighten lock nut (57) after adjustment is completed. Do not adjust when regulator is closed (no flow). Only adjust when gas is flowing through regulator (approximately 250 SCFH).

Except for lock-up (regulator closed), the outlet pressure during normal operation must not go higher than the maximum limit of the spring range. Whenever it goes

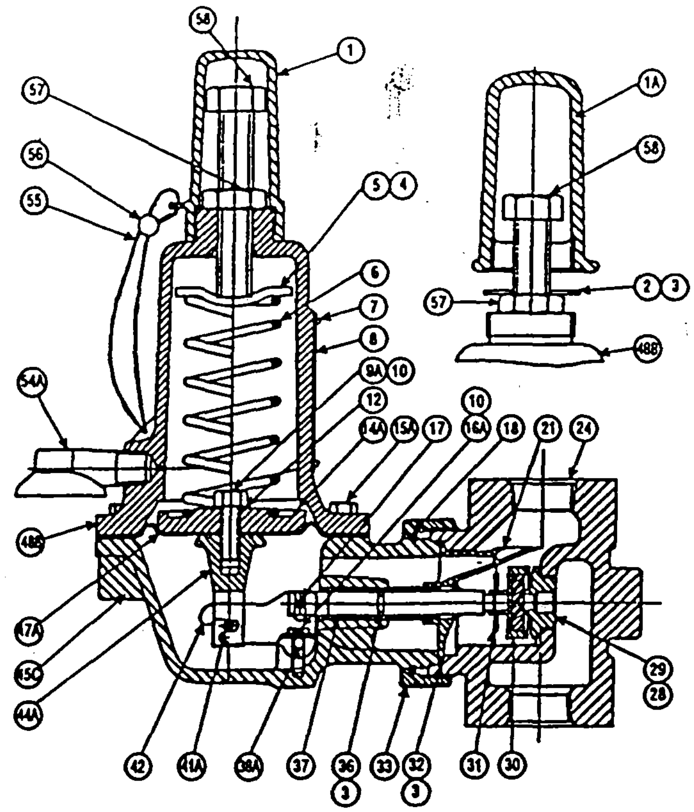
(Continued on Page 2)

Model	Body	Diaphragm Case	Internal Relief Valve	Maximum Inlet Pressure	Outlet Pressure Range
046	Ductile Iron ASTM 395 GR 60-90-18	Aluminum	No	SEE TABLES ABOVE	3 to 200 psi
046-M[1]		Aluminum	No		
046-C		Cast Iron	No		
046-CM[1]		Cast Iron	No		
046-2		Aluminum	Yes		3 to 125 psi
046-2M[1]		Aluminum	Yes		
046-PL		Aluminum	No		5 to 100 psi
046-CPL		Cast Iron	No		

1. Regulator requires a control line.



MODEL NO. 046



MODEL NO. 046-C

higher, the spring could be overstressed. Also, the higher pressure springs could compress solid and thereby keep the regulator from closing.

Therefore, whenever set-point is within the upper third of the spring range, set-point adjustment should be made at low flow (Approximately 250 SCFH). If set-point adjustment must be made when flow is greater, use the next higher range spring.

CAUTION

It is the user's responsibility to assure that all regulator vents and/or vent lines exhaust to a non-hazardous location away from any potential sources of ignition. Where vent lines are used, it is the user's responsibility to assure that each regulator is individually vented and that common vent lines are not used.

8 The vent connection (54) or (54A) is an escape path for flammable gas and it must be located and/or piped so that potential discharge occurs in a safe area away from buildings, open flames, collection areas, arcing devices, etc.

Regulators that are installed indoors or in an non-vented area must be vented to the outside. Simply run vent piping from the regulator vent connection to a non-hazardous location on the outside away from any potential sources of ignition. The vent piping must be a minimum 1/4 NPT, connection size or larger and piped to a safe area. The vent discharge must be protected against the potentials outlined in instructions #4, #8, #9 and #10.

For regulators equipped with internal relief valves (IRV), models 046-2 & 046-2M, vent piping must be vent connection size (1" NPT) or larger. This will assure that the vent piping will be large enough to be able to vent all of the internal relief valve discharge to atmosphere without excessive back pressure that would result in excessive pressure increase in the regulator.

The outlet of the vent piping must allow for the free and unobstructed passage of air and gas and must be protected against the potentials listed in instructions #4, #8, #9 and #10.

9 For outdoor installations, it is recommended that the regulator be installed so that the regulator vent faces downward to avoid the potential for water or other foreign matter entering the regulator and interfering with the proper operation of the regulator.

10 For application on combustible gas with a specific gravity greater than 1.0 (such as propane) it is recommended that the gas be vented outdoors where the gas will not collect in low areas and away from all open flames, arching devices, etc.

CAUTION

Regulators are pressure control devices with numerous moving parts subject to wear. Regulator wear is dependent upon particular operating conditions. To assure continuous satisfactory operation, a periodic inspection schedule must be adhered to with the frequency of inspection determined by the severity of service and applicable laws and regulations.

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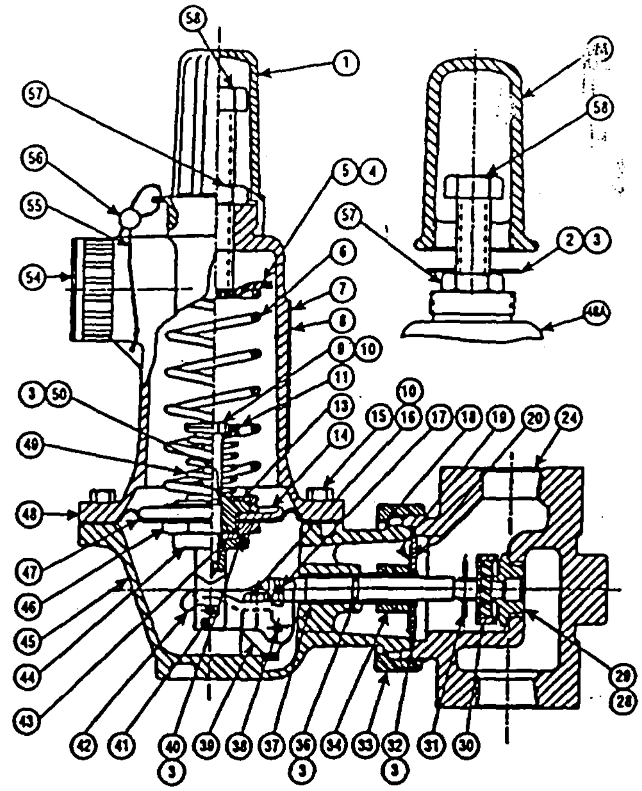
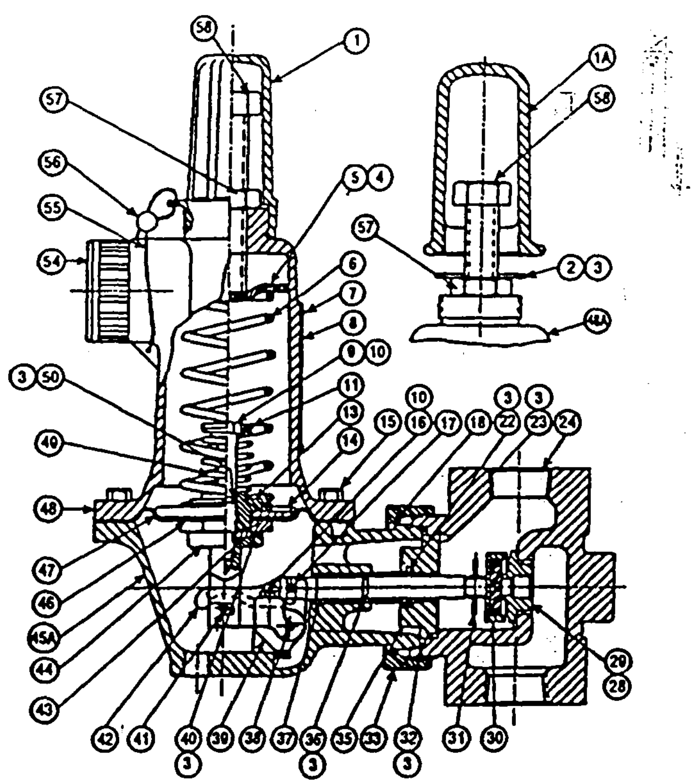


MODEL NO. 046-2



MODEL NO. 046-2M

Service

1 Make sure regulator is entirely depressured before disassembling.

2 In general, it is not necessary to disconnect the body (24) from the piping. Leave it in place in the line when servicing the regulator.

3 Carefully note location and position of each part during disassembly to make certain reassembly is correct. Replace all worn, damaged, or otherwise unsatisfactory parts.

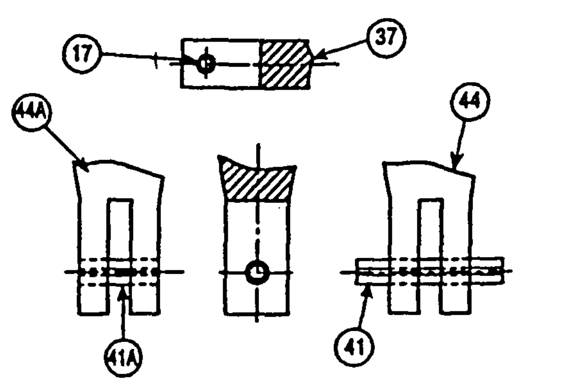
4 To service valve or orifice, first loosen coupling nut (33) and separate diaphragm case assembly from body. Remove and inspect body to lower case seal ring (32). Replace if damaged. To remove valve (30), first remove snap clip (31). Orifice (29) unscrews from body using 1" hex socket wrench "thin-wall" type. Use moderate amount of pipe dope on sealing surface (male threads) when replacing orifice.

5 During reassembly, make sure tetraseal (32) is correctly positioned. Tighten coupling nut (33) with a torque of 35 to 50 ft.-lbs.

6 To change spring (6), after removing cover cap (1) or (1A), turn adjustment screw (58) counterclockwise to remove spring load. Remove screws (15) or (15a) and upper diaphragm case (48), (48A) or (48B) and spring ferrule (5). Make sure new spring is correctly nested on the diaphragm pan (14) or (14A) and install spring ferrule (5) at reassembly. Also, make sure diaphragm (47) or (47A) is not pinched.

7 To replace diaphragm, follow step 6 during disassembly and reassembly. Remove screw (9A) to disassemble diaphragm assembly and remove diaphragm (47) or (47A). On regulators with internal relief valve (all -2 models), remove IRV bolt (9), and IRV spring (49) slowly, as force is required to keep spring from expanding rapidly. Remove diaphragm coupling nut (46) and replace diaphragm (47). Assemble the diaphragm (47) in reverse order. Inspect IRV "O" Rings (50) and (40), replace if necessary. Align coupling pin (41) parallel and square to the diaphragm centerline. Make sure roll pin (41) or (41A) is correctly positioned as shown. On reassembly, tighten screws (15) or (15A) evenly to a torque of 125 in.-lbs. The screws must be tight enough to prevent leakage but not so tight as to crush or damage the diaphragm. The diaphragm coupling roll pin (41) or (41A) must be assembled parallel and square to the diaphragm centerline to prevent binding of the coupling (44) or (44A) and lever (42). Also, the diaphragm (47) or (47A) must not be twisted or pinched.

8 Upon completing servicing, make sure regulator is free of leaks.



ROLL PIN POSITIONING

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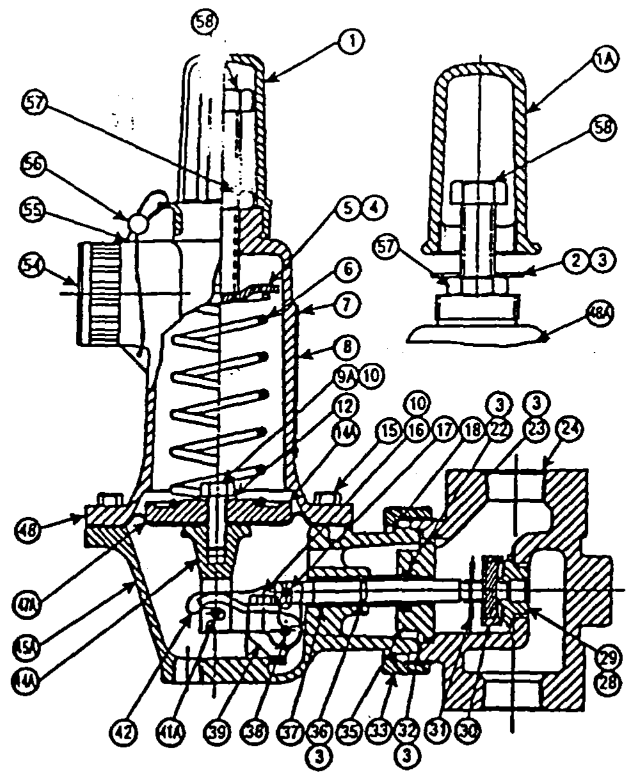
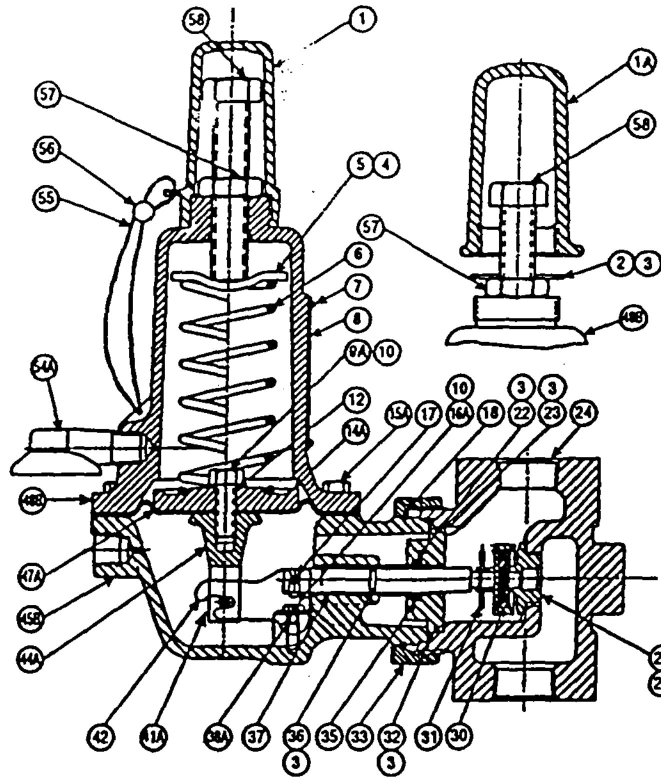


MODEL NO. 046-M



MODEL NO. 046-CM

046 Parts List

The following are the parts for the 046 regulators. Those parts generally required in maintenance and servicing are highlighted.

ITEM NO.	PART NO.	DESCRIPTION
1	046-00-005-00	Cover cap
1a	046-00-005-01	Cast iron cover cap
2	950805	**Tetraseal, buna-n**
	950806	**Tetraseal (or o-ring), viton**
3	1191074	**O-ring lube**
4	1191073	**Aero-lubriplate**
5	141-62-009-00	Spring ferrule
6	See chart	**Spring**
7	914760	#0 x 1/8 lg. drive screw
8	046-00-086-00	Nameplate
	046-00-086-01	Nameplate (taipei city)
9	046-00-153-00	**IRV shoulder screw**
9a	910029	**5/16-18 x 7/8 lg hex stl cap scr**
10	906114	Locktite 242
11	046-00-009-00	**Spring holder**
12	904983	**Stat-o-seal (high temp only)**
13	046-00-074-00	**Guide bushing**
14	046-00-022-01	**Diaphragm pan (IRV)**
14a	046-00-022-00	**Diaphragm pan**
15	903163	**1/4-20 x 3/4 lg hex hd stl thd form**
	903164	**1/4-20 x 3/4 lg hex hd s.s. thd form**
15a	907558	**1/4-20 x 5/8 lg hex hd cap scr**
	950550	**1/4-20 x 5/8 lg hex hd cap scr s.s.**
16	903164	**1/4-20 x 3/4 lg hex hd s.s. thd form**
16a	903314	**#10-24 x 1/2 lg bind hd mach scr s.s.**
17	950381	**Spirol pin 5/32 x 5/16 lg**
18	141-62-130-00	**Retaining ring**
19	141-62-035-00	**Stabilizer disc**
20	141-62-034-00	**Stabilizer**

ITEM NO.	PART NO.	DESCRIPTION
21	141-62-045-00	**Boost tube**
22	934010	**O-ring, buna-n**
	902987	**O-ring, viton**
23	908771	**O-ring, buna-n**
	950746	**O-ring, viton**
24	046-00-001-06	Body, 3/4" conn.
	046-00-001-04	Body, 1" conn.
	046-00-001-05	Body, 1 1/4" conn.
24a	046-00-001-09	Body, 3/4" conn. w/inlet tap
	046-00-001-10	Body, 1" conn. w/inlet tap
	046-00-001-11	Body, 1 1/4" conn. w/inlet tap
25	903989	Tub elbow 3/8 x 1/4
26	903973	Conn. 3/8 tube x 1/4 npt
27	51125	Tube 3/8 od x .035 wall x 10" lg
28	905115	Locktite 222 mild
29	046-00-023-02	**1/8 s.s. valve orifice**
	046-00-023-03	**3/16 s.s. valve orifice**
	046-00-023-04	**1/4 s.s. valve orifice**
	046-00-023-05	**5/16 s.s. valve orifice**
	046-00-023-06	**3/8 s.s. valve orifice**
	046-00-023-07	**1/2 s.s. valve orifice**
	046-00-023-22	**1/8 brass valve orifice**
	046-00-023-23	**3/16 brass valve orifice**
	046-00-023-24	**1/4 brass valve orifice**
	046-00-023-25	**5/16 brass valve orifice**
	046-00-023-26	**3/8 brass valve orifice**
	046-00-023-27	**1/2 brass valve orifice**
30	141-62-511-03	**Valve ass'y, buna-n**
	141-62-511-01	**Valve ass'y, poly-u**
	141-62-511-04	**Valve ass'y, viton**

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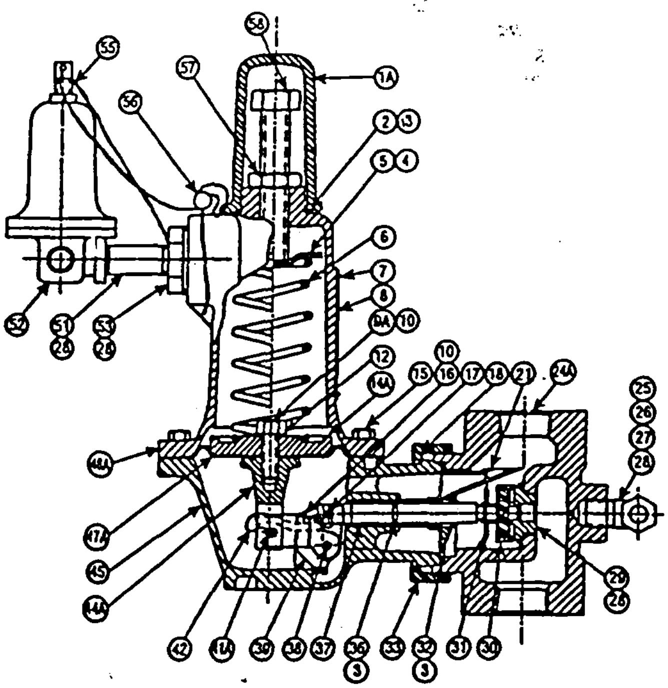
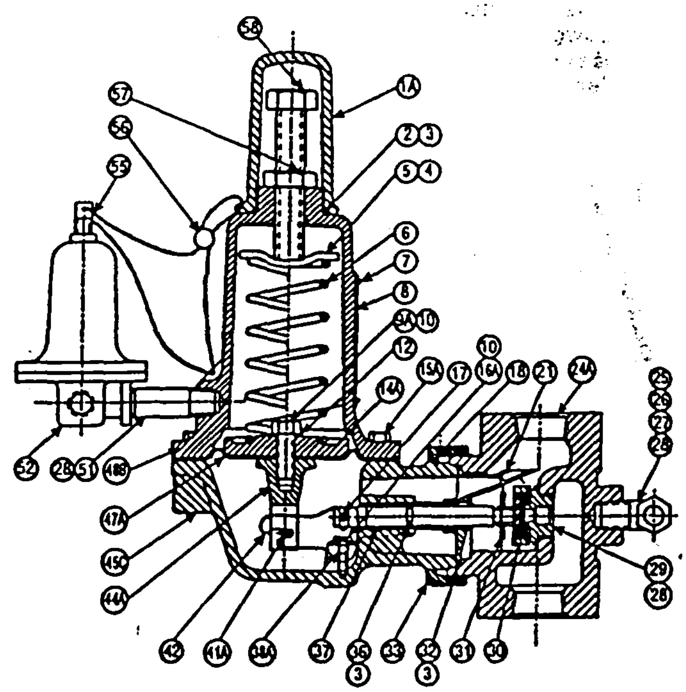


MODEL NO. 046-PL



MODEL NO. 046-CPL

046 Parts List

The following are the parts for the 046 regulators. Those parts generally required in maintenance and servicing are highlighted.

ITEM NO.	PART NO.	DESCRIPTION
31	141-62-118-00	Snap clip
32	902497	Tetraseal, buna-n
	907718	Tetraseal (or o-ring), viton
33	143-62-102-02	Coupling nut
34	141-62-036-00	Stabilizer hub
35	046-00-038-00	Monitor throat block
36	934005	O-ring, buna-n
	904839	O-ring, viton
37	046-00-016-00	Valve stem, brass
	046-00-016-01	Valve stem, s.s.
38	950728	Fulcrum dowel pin 3/16 x 3/4 lg s.s.
38a	141-62-033-00	Fulcrum pin
39	046-00-029-00	Pivot bracket
40	904824	O-ring, buna-n
41	901695	IRV roll pin, 3/16 x 1 1/4 lg
41a	901697	Roll pin 3/16 x 5/8 lg
42	046-00-030-00	Lever
43	046-00-154-00	IRV coupling disc
44	046-00-028-01	Diaphragm coupling (IRV)
44a	046-00-028-00	Diaphragm coupling
45	046-00-602-01	Lower case s.s. bushing ass'y
	046-00-602-00	Lower case brass bushing ass'y
45a	046-00-602-03	Monitor lower case s.s. bushing ass'y
	046-00-602-02	Monitor lower case brass bushing ass'y
45b	046-00-602-05	Monitor lower case s.s. bushing ass'y
	046-00-602-04	Monitor lower case brass bushing ass'y
45c	046-00-602-07	Lower case s.s. bushing ass'y
	046-00-602-06	Lower case brass bushing ass'y

ITEM NO.	PART NO.	DESCRIPTION
46	046-00-155-00	Clamping nut
47	046-00-150-01	IRV diaphragm, buna-n
47a	046-00-150-00	Diaphragm, buna-n
	046-00-150-02	Diaphragm, viton
48	046-00-003-00	Upper case, alum
48a	046-00-003-02	Upper case, alum w/thd's
48b	046-00-003-01	Upper case, cast iron w/thd's
49	080-02-021-01	Spring-blue (IRV)
50	934003	O-ring, buna-n
51	924059	Nipple 1/4 x 2"
52	1191495	Pilot 67R 2-20 psi
	1191496	Pilot 67R 5-35 psi
	1191497	Pilot 67R 30-60 psi
	1191498	Pilot 67R 35-100 psi
	1191409	Pilot 67RS 2-20 psi
	1191410	Pilot 67RS 5-35 psi
	1191411	Pilot 67RS 30-60 psi
	1191412	Pilot 67RS 35-100 psi
53	904397	Hex bushing 1" npt to 1/4 npt
54	046-00-527-00	Vent cap assembly
54a	137-02-505-03	Vent assembly
55	001-63-057-50	Seal wire 12" lg
56	001-60-157-00	Seal
57	921006	9/16-12un hex stl jam nut
58	950655	9/16-12 x 3" lg hex hd stl cap scr
Not Shown	046-62-086-04	Customer badge

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er Pressurization Protection

Protection must be provided for the downstream piping system and the regulator's low pressure chambers to assure against the potential over pressurization due to a regulator malfunction or a failure of the regulator to lock-up. The allowable over pressurization is the lowest of the maximum pressures permitted by federal codes, state codes, Equimeter Bulletin RDS-1498, or other applicable standards. The method of providing over pressure protection could be a relief valve, a monitor regulator, a shut off device or any similar device.

Internal Relief Valve (IRV) Capacity

Internal Relief Valves, like all relief valves must be carefully checked for adequate capacity. IRV's only have full capacity relief capability when the inlet pressure to the regulator is low enough and the regulator orifice is small enough. If either one, or both, are too large, the IRV will not have full capacity relief capability and will not be able to prevent the outlet pressure from exceeding the maximum allowable limit.

Capacity for the full open 046 IRV can be calculated from the formula

$Q = \frac{KP_0}{2}$ for 0.6 specific gravity gas

where

K = 600 (the IRV constant)
P_0 = absolute outlet pressure (psia)

Field regulators with internal relief valves can be obtained by specifying Models 046-2, or 046-2M. The 046-2M is a limited capacity IRV unit due to flow through the control line.

Spring Ranges

046, 046-M, 046-C & 046CM Models

Outlet Pressures	Spring Color	Part Number
3 to 10 psi	Yellow	141-62-021-00
8 to 20 psi	Aluminum	141-62-021-01
15 to 52 psi	White	141-62-021-02
50 to 125 psi	Tan	141-62-021-03
100 to 200 psi	Gray	141-62-021-04
10 to 95 psi	Dark Green[1]	141-62-021-05

046-2, 046-2 Models

Outlet Pressures	Spring Color	Part Number
3 to 10 psi	Yellow	141-62-021-00
8 to 20 psi	Aluminum	141-62-021-01
15 to 52 psi	White	141-62-021-02
50 to 125 psi	Tan	141-62-021-03
10 to 95 psi	Dark Green[1]	141-62-021-05

1. General Purpose Spring.

Spring Ranges and Combinations

046-PL & 046-CPL

For This Outlet Pressure Range	Use These Springs 046 Regulator	Loading Regulator
5 to 15 psi	Yellow 3 psig	2 to 20 psig
15 to 25 psi	Yellow 10 psig	2 to 20 psig
20 to 40 psi	Yellow 10 psig	5 to 35 psig
30 to 50 psi	Alum. 20 psig	5 to 35 psig
50 to 75 psi	Alum. 20 psig	30 to 60 psig
60 to 100 psi	Alum. 20 psig	35 to 100 psig

Full Open Capacity

Use the following formulas for calculating the full open capacity of 046 regulators. Do not use full open capacity when sizing one of these regulators for an application. Instead, use the capacity tables in Bulletin R-1312.

1. $Q = K\sqrt{Po\,(Pi-Po)}$

2. $Q = \frac{KPi}{2}$

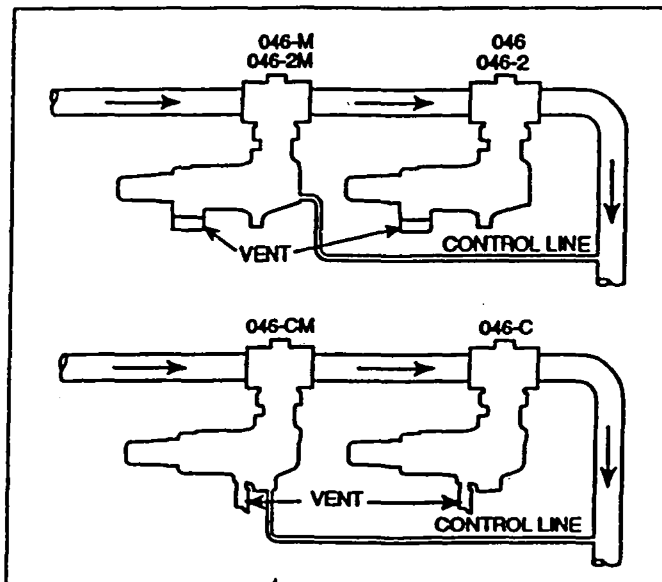
Q = maximum capacity of the regulator (in SCFH of 0.6 specific gravity natural gas).
K = the "K" factor, the regulator constant (from table below).
Pi = absolute inlet pressure (psia).
Po = absolute outlet pressure (psia).

Use formula 1. when $\frac{Pi}{Po}$ is less than 1.894.

Use formula 2. when $\frac{Pi}{Po}$ is greater than 1.894.

Orifice	1/8"	3/16"	1/4"	5/16"	3/8"	1/2"
"K" Factor	33	74	132	206	292	520

When sizing relief valves for use with 046 regulators, use full open capacity as calculated with the above formulas. Do not use values from the capacity tables in bulletin R-1312.



MONITOR SET

Monitoring

The 046 regulator makes an excellent monitor; a standby regulator installed in series which assumes control if a failure in the operating regulator permits the outlet pressure to exceed the set-point. It can be located in either the upstream or the downstream position.

When an 046 is used to monitor a regulator with an identical inner valve (another 046), the total maximum capacity through both regulators can be figured at 70% of the capacity of one of them alone. This applies with the monitor located either up or downstream.

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Maximum Emergency Pressure

The maximum pressure the regulator inlet may be subjected to under abnormal conditions without causing damage to the regulator is:

046, 046-2, 046-C, 046-CM, 046M, 046-2M, 046-PL and 046-CPL .... Max. Inlet Pressure +100 psi

The maximum pressure the regulator outlet may be subjected to without causing damage to the internal parts of the regulator is:

For set-points of 3 to 200 psi .... set point +100 psi

Set-point is defined as the outlet pressure a regulator is adjusted to deliver.

If any of the above pressure limits are exceeded, the regulator must be taken out of service and inspected. Damaged or otherwise unsatisfactory parts must be replaced or repaired.

The maximum pressure that can be safely contained by the diaphragm case is:

046, 046-2, 046-C, 046-CM, 046-M, 046-2M, ... 400 psi
046-PL & 046-CPL .... 250 psi

Safely contained means no leakage as well as no bursting.

Temperature Limits

The 046 Regulators can be used for flowing temperatures from -20°F. to 150°F.

Other Gases

The 046 Regulators are mainly used on natural gas services; however, these regulators will perform equally as well on other gases. When using the 046 Regulators on other gases, the regulator capacities must be adjusted using the following correction factors.

Type of Gas	Correction Factor
Air (specific gravity 1.0)	0.77
Propane (specific gravity 1.53)	0.63
1350 BTU Propane-Air Mixture (specific gravity 1.20)	0.71
Nitrogen (specific gravity 0.97)	0.79
Dry CO_2 (specific gravity 1.52)	0.63

For other noncorrosive gases use the following formula:

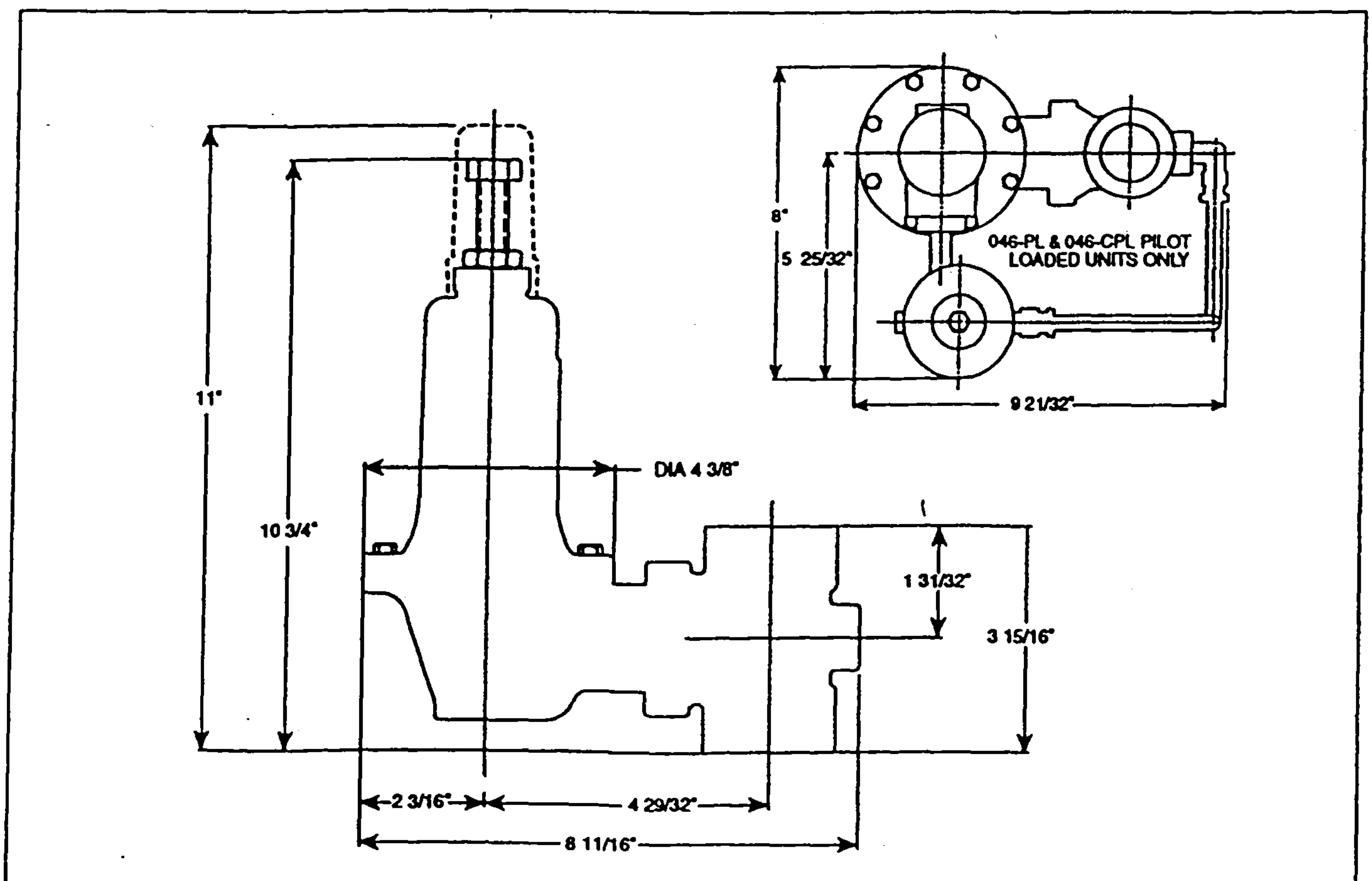
$$\text{Correction Factor} = \sqrt{\frac{0.60}{\text{Specific gravity of the Gas}}}$$

For use with gases not listed above, please contact your Equimeter representative or Industrial Distributor for recommendations.

Buried Service

The 046 Regulators *are not* recommended for buried service.

Dimensions



Thermal oxidizer - gray

Ameron

Amercoat® 385

Multi-purpose epoxy

Product Data

- Primer for durable systems with wide range of topcoats, including polyurethanes and acrylics
- Rust inhibitive epoxy primer
- Suitable for variety of substrates
- Excellent shop primer for corrosive service
- Suitable for immersion service
- Outstanding chemical and weather resistance
- Excellent adhesion to inorganic zinc silicate
- Easy application
- No lead pigments added to 385PA
- VOC compliant
- Wide film build range
- Compatible with compromised surface preparation

Amercoat 385 is a high-performance coating forming a tough, abrasion-resistant, durable film. It adheres strongly to bare steel, coated steel and inorganic zinc silicate coated surfaces on new construction, repair and field maintenance projects. A[illegible]coat 385 will also adhere to intact painted surfaces and t[illegible]st and may be used to repair itself or inorganic zinc silicate primers.

Amercoat 385 provides an excellent barrier to corrosion; its inhibitive pigment version (385PA) affords protection at damaged areas. It has high chemical resistance, making it suitable for use in aggressive environments. Amercoat 385 is user-friendly and can be applied by a variety of spray methods to produce a smooth, fast-drying film. It is suitable for immersion in both salt and fresh water at temperatures up to 140°F, continuous and can be used as a tank lining for alkaline and salt solutions, petroleum fuels, sewage waste and certain chemicals. Amercoat 385PA contains no added lead pigments and has a low VOC.

Amercoat 385 is suitable as a primer for certain tank lining systems. It may also be applied over aluminum, stainless steel, galvanizing, concrete and previously coated surfaces in addition to steel.

Amercoat 880 glassflake may be added to increase film build and lower moisture vapor permeability. For additional information see Amercoat 880 Product Data Sheet or contact your Ameron representative.

Typical Uses

- Industrial structural steel, machinery and piping.
- Tank exteriors in oil refineries, paper mills, chemical processing facilities and waste water treatment plants.
- Decks, hulls and superstructures of ships, barges and work [illegible]
- [illegible], offshore platforms and related structures.
- Tank lining.

Physical Data

Finish	Flat			
Color				
Amercoat 385	Ameron standard colors See color card			
Amercoat 385PA Inhibitive pigment	Oxide red, white, off-white			
Components				
385 or 385PA	2			
385AL	3			
Curing mechanism	Solvent release and chemical reaction between components			
Volume solids (ASTM D2697 modified)				
385 or 385PA	66% ± 3%			
385AL	58% ± 3%			
Dry film thickness per coat				
385 or 385PA	4 to 6 mils (100 to 150 microns)			
with 880 glassflake	6 to 14 mils (150 to 350 microns)			
Coats	1 or 2			
Theoretical coverage	ft²/gal		m²/L	
385 or 385PA				
1 mil (25 microns)	1059		26.0	
4 mils (100 microns)	265		6.5	
385AL				
1 mil (25 microns)	936		23.0	
4 mils (100 microns)	234		5.7	

385 with 880 at 6 mils (150 microns) will be 199 ft² per gallon of 385

VOC	lb/gal		g/L	
(EPA method 24)				
385 mixed	2.3		276	
385 mixed/thinned	2.6		311	
(calculated)				
385AL mixed	2.9		347	
385AL mixed/thinned	3.2		383	
Temperature	Wet		Dry	
	°F	°C	°F	°C
continuous	140	60	200	93
intermittent	175	79	250	121
Flash point (SETA)	°F		°C	
385 cure	118		48	
385 resin	128		53	
385AL cure & resin	85		29	
385AL paste	108		42	
Amercoat 861	300		149	
Amercoat 7	102		39	
Amercoat 65	78		25	
Amercoat 101	145		63	
Amercoat 12	0		-18	

Qualifications

Military Sealift Command	Underwater hulls, topside and salt water ballast tank service
NAVSEA	Chapter 631 for aluminum hull use

Typical Properties

Physical

Abrasion (ASTM D4060) 1 kg load/1000 cycles CS-17 wheel	108 mg weight loss
Adhesion, Elcometer (ASTM D4541)	>1000 psi

Performance

Salt spray – 1 coat @ 6 mils 5000 hours exposure	
face corrosion (ASTM B117)	None
face blistering (ASTM B117)	None
Humidity (condensation) (ASTM D4588) 3000 hours exposure	
face corrosion	None
Steam cleanable	Yes
Chemical resistance – Condition after 1 year immersion	
caustic 30%, 50% up to 140°F	Excellent
fuel (MSC recipe)	Excellent
salt water	Excellent
DI water up to 140°F	Excellent

Amercoat 385 Chemical Resistance Guide

Environment	Splash and Spillage	Fumes and Weather
Acidic	F	G
Alkaline	E	E
Solvents	E	E
Salt solutions		
Acidic	G	VG
Neutral	E	E
Alkaline	E	E
Water	E	E

F-Fair G-Good E-Excellent VG-Very Good

This chart shows typical resistance of Amercoat 385. Contact your Ameron representative for your specific requirements.

Systems Using Amercoat 385

1st Coat	2nd Coat	3rd Coat
Amercoat 385 or 385PA	–	–
Amercoat 385 or 385PA	Amershield™	–
Amercoat 385 or 385PA	450HS	–
Dimetcote® 9, 9FT, 21-9	385	Amershield, 450HS
Amercoat 68A, 68HS,	385	Amershield, 450HS
Amercoat 385	385	698HS, 70ESP, 635, 279, 275E 277E

Confirm compliance with VOC regulations before using coating systems. For immersion service, apply 2 coats at a minimum of 8 mils total DFT.

Over Dimetcote, Amercoat 68A and 68HS primers, a mist coat and thinning with Amercoat 101 may be required to prevent application bubbling.

Use Amercoat 385PA primer when inhibitive pigmented primer is specified as the first coat.

Application Data

Applied over substrates	Steel, concrete, masonry block, aluminum, galvanizing, coated surfaces
Primer/s	See Systems Table
Method	Airless, conventional spray, brush or roller
Mixing ratio (by volume)	
385 or 385PA	1 part resin to 1 part cure
385AL	0.42 cure to 0.43 resin to 0.15 paste
385 with 880 glassflake	1-gal 880 per mixed 2-gal 385 2½ gal 880 per mixed 5-gal 385

Pot life (hours) °F/°C

	90/32	70/21	50/10
385 or 385PA	1½	3	5
385 with 880 glassflake	1½	2½	4
385 accelerated with 1 pt 861/5 gal	½	1	3

Environmental conditions

Temperature	°F	°C
air and surface	40 to 120	4 to 49

Surface temperatures must be at least 5°F (3°C) above dew point to prevent condensation.

Drying time (ASTM D1640) @ 6 mils, DFT (hours) °F/°C

	90/32	70/21	50/10	32/0
touch	1	2	3	6
through	10	16	24	168
with 880 glassflake	12	18	26	192
Topcoat or recoat time				
minimum	6	8	10	72

Addition of 861 Accelerator does not change dry-to-touch or dry-through times but does accelerate cure for service.

Topcoat or recoat time (days) (maximum) °F/°C

	90/32		70/21		50/10	
Product	385	w/861	385	w/861	385	w/861
450HS,	14	3	30	7	42	14
Amershield™	14	3	30	7	42	14
385 or 385PA						
non-immersion	No maximum – Clean surface required					
immersion	6 months – high pressure water wash or roughen surface if exceeded					
698HS, 70ESP, 635, 279, 275E, 277E	Apply while 385 is tacky, soft to fingernail					

Failure to apply antifoulings while coating is still tacky or soft to fingernail may result in poor adhesion and eventual delamination.

Time before service @ 8 mils (hours) °F/°C

385 or 385PA	90/32	70/21	50/10	32/0
immersion				
ambient	24	48	72	240
hot	72	168	336	NR
non-immersion	12	24	36	168
385 or 385PA accelerated @ 1 pt 861/5 gal				
immersion				
ambient	12	24	48	168
hot	36	72	168	NR
non-immersion	6	12	24	96

NR=Not recommended

Thinners (up to ½ pt)	
above 70°F (21°C)	Amercoat 7 or 101
below 70°F (21°C)	Amercoat 65

In confined areas thin with Amercoat 7 or 101

Equipment cleaner — Thinner or Amercoat 12

Application Data Summary

See Application Instructions for complete information on surface preparation, environmental conditions, application ...cedures and equipment. To obtain maximum performance, ...ly as recommended. Adhere to all safety precautions during storage, handling, application and drying periods.

This product is for professional use only. Not for residential use in California.

Warranty

Ameron warrants its products to be free from defects in material and workmanship. Ameron's sole obligation and Buyer's exclusive remedy in connection with the products shall be limited, at Ameron's option, to either replacement of products not conforming to this Warranty or credit to Buyer's account in the invoices amount of the nonconforming products. Any claim under this Warranty must be made by Buyer to Ameron in writing within five (5) days of Buyer's discovery of the claimed defect, but in no event later than the expiration of the applicable shelf life, or one year from the delivery date, whichever is earlier. Buyer's failure to notify Ameron of such nonconformance as required herein shall bar buyer from recovery under this Warranty.

Ameron makes no other warranties concerning the product. No other warranties, whether express, implied, or statutory, such as warranties of merchantability or fitness for a particular purpose, shall apply. In no event shall Ameron be liable for consequential or incidental damages.

Any recommendation or suggestion relating to the use of the products made by Ameron, whether in its technical literature, or in response to specific inquiry, or otherwise, is based on data ...eved to be reliable; however, the products and information ...ntended for use by Buyers having requisite skill and know-how in the industry, and therefore it is for Buyer to satisfy itself of the suitability of the products for its own particular use and it shall be deemed that Buyer has done so, at its sole discretion and risk. Variation in environment, changes in procedures of use, or extrapolation of data may cause unsatisfactory results.

Limitation of Liability

Ameron's liability on any claim of any kind, including claims based upon Ameron's negligence or strict liability, for any loss or damage arising out of, connected with, or resulting from the use of the products, shall in no case exceed the purchase price allocable to the products or part thereof which give rise to the claim. **In no event shall Ameron be liable for consequential or incidental damages.**

Shipping Data

Packaging		
385 or 385PA	2- and 5-gal units	
385AL	1- and 10-gal units	
Shipping weight (approx.)	lb	kg
385 or 385PA 2-gal unit		
cure 1 gal in 1-gal can	12	5.6
resin 1 gal in 1-gal can	13	6.0
385 or 385PA 5-gal unit		
cure 2.5 gal in 5-gal can	31	14.3
resin 2.5 gal in 2½-gal can	34	15.3
385AL 1-gal unit		
cure 0.42 gal in 1-gal can	4	1.9
resin 0.43 gal in 1-gal can	5	1.7
paste 0.15 gal in 1-qt can	2	1.0
385AL 10-gal unit		
cure 4.2 gal in 5-gal can	36	16.2
resin 4.3 gal in 5-gal can	40	18.3
paste 1.5 gal in 2½-gal can	23	10.5

Shelf life when stored indoors at 40 to 100°F (4 to 38°C)

cure, resin and paste — 1 year from shipment date

Numerical values are subject to normal manufacturing tolerances, color and testing variances. Allow for application losses and surface irregularities. See application instructions for complete information and safety precautions.

The mixed product is photochemically reactive as defined by the South Coast Air Quality Management District's Rule 102 or equivalent regulations.

Amercoat® 385

Multi-purpose epoxy

Application Instructions

Refer to the Product Data Sheet for properties and uses. Adhere to all application instructions, precautions, conditions and limitations to obtain the maximum performance. When used over recommended primers, refer to Application Instructions for the specific primer being used for surface preparation data and application and drying procedures. For conditions outside the requirements or limitations described, contact your Ameron representative.

Surface Preparation

Coating performance is proportional to the degree of surface preparation. Refer to specifications for the specific primer being used. Prior to coating, primed surface must be clean, dry, undamaged and free of all contaminants including salt deposits. Round off all rough welds and remove all weld spatter.

Steel – Remove all loose rust, dirt, grease or other contaminants by one of the following depending on the degree of cleanliness required: SSPC-SP2, 3, 6 or 7. Water blasting is also acceptable. For more severe service and immersion, clean to SSPC-SP10. The choice of surface preparation will depend on the system selected and end-use service conditions.

to achieve a surface profile not to exceed 3 mils (.. microns) as indicated by a Keane-Tator Surface Profile Comparator Testex Tape. Increase coating thickness if profile greater than 3 mils.

Galvanizing – Remove oil or soap film with neutral detergent or emulsion cleaner; then use zinc treatment such as Galvaprep® or equivalent or blast lightly with fine abrasive.

Aluminum – Remove oil, grease or soap film with neutral detergent or emulsion cleaner; treat with Alodine® 1200, Alumiprep® or equivalent or blast lightly with fine abrasive.

Concrete/masonry – Surface must be cured, clean, dry, free of contamination and disintegrated or chalky materials. Clean concrete surface; abrasive blast (ASTM D4259) or acid etch (ASTM D4260). Fill concrete voids with Nu-Klad® 965 or 114A to achieve a smooth surface. Clean masonry surface by ASTM D4261. Fill masonry block with Amerlock® 400BF Block Filler.

Aged coatings – All surfaces must be clean, dry, tightly bonded and free of all loose paint, corrosion products or chalky residue. Clean by pressure water blast (1000 psi or greater), SSPC-SP1, 2, 3 or 7. Amercoat 385 is compatible over most types of properly applied and tightly adhering coatings. However, a test patch is patch is recommended to confirm compatibility.

Repair – Prepare damaged areas to original surface preparation specifications, feathering edges of intact coating. Thoroughly remove dust or abrasive residue before touch up.

Environmental Conditions

Temperature	°F	°C
and surface	40 to 120	4 to 49

Surface temperature must be at least 5°F (3°C) above dew point to prevent condensation. At freezing temperatures surfaces must be free of ice.

Application Equipment

Airless spray – Standard equipment such as Graco Bulldog Hydra-Spray or larger with a 0.15- to 0.021- in. (0.38 to 0.53 mm) fluid tip.

Conventional spray – Industrial equipment such as DeVilbiss MBC or JGA spray gun with 78 or 765 air cap and "E" fluid tip, or Binks No. 18 or 62 gun with a 66 x 63PB nozzle set up. Separate air and fluid pressure regulators, mechanical pot agitator, a moisture and oil trap in the main air supply line are recommended.

Power mixer – Jiffy Mixer powered by an air or an explosion-proof electric motor.

Brush – Natural bristle. Maintain wet edge.

Roller – Use industrial roller. Level any air bubbles with bristle brush.

Application Procedure

Amercoat 385 or 385PA consists of two components which must be mixed together before use. It is packaged in the proper portions in 2- or 5-gallon units. Amercoat 385AL consists of three components packaged in the proper portions and is available in 1- or 10-gallon units.

1. Flush equipment with thinner or Amercoat 12 before use.
2. Stir each component thoroughly, then combine resin and cure and mix until uniform. For 385AL, stir each component thoroughly, add aluminum paste to resin, mix until uniformly blended then add cure and stir again until uniformly blended. When using Amercoat 880 glassflake, add material to mixed unit of Amercoat 385 following 880.
3. Thin only if necessary for workability, add Amercoat 101 up to 1/2 pint (approximately 6%) per gallon of Amercoat 385. Use Amercoat 65 when faster drying is desired. Use Amercoat 7 or 101 when applying in confined spaces. Use only Ameron recommended thinners.
4. Do not mix more material than will be used within pot life. Pot life is shortened by higher temperatures.

Pot life (hours)	°F/°C		
	90/32	70/21	50/10
385	1 1/2	3	5
385 with 880	1 1/2	2 1/2	4
385 accelerated @ 1 pt 861/5-gal	1/2	1	3

5. Amercoat 861 Accelerator may be used for applications when low temperatures are expected or to achieve faster time to service at temperatures below 50°F. When 861 is used with white or light colors of Amercoat 385, a color variation may result. Do not use more than 1 pint Amercoat 861 per 5-gallon unit.
6. For conventional spray, use adequate air pressure and volume to ensure proper atomization.
7. Apply a wet coat in even, parallel passes; overlap each pass 50 percent. If required, cross-spray at right angles to avoid holidays, bare areas and pinholes.

Note: When applying directly over inorganic zincs or zinc-rich primers, a mist coat may be required to minimize bubbling. This will depend on the age of the Dimetcote, surface roughness and conditions during curing.

8. When applying antifouling coatings, apply first antifouling coat while Amercoat 385 is still tacky or soft to fingernail. Failure to apply antifouling while Amercoat 385 is still tacky may result in poor adhesion between coatings and eventual delamination of the antifouling.

9. Normal recommended dry film thickness per coat is4 to 6 mils for 385 and 6 to 14 mils for 385 with 880. However, if greater thickness is applied in local areas because of overlapping, no runs or sags will normally occur at a dry film thickness up to 10 mils for 385 and 16 mils for 385 with 880. Total dry film thickness in two coats must not exceed 16 mils for 385 and 32 mils for 385 with 880.

10. A wet film thickness of 6 mils (150 microns) normally provides 4 mils (100 microns) of dry film.

11. When using brush or roller application method, additional coats may be required to achieve proper film thickness.

12. When used as a tank lining, check film continuity of material with a nondestructive holiday detector such as Tinker and Rasor Model M-1. Apply additional Amercoat 385 to areas requiring touch up.

13. Clean all equipment with thinner or Amercoat 12 immediately after use.

Drying time (ASTM D1640) @ 6 mils, DFT (hours)

	°F/°C			
	90/32	70/21	50/10	32/0
touch	1	2	3	6
through	10	16	24	168
with 880 glassflake	12	18	26	192
Topcoat or recoat time				
minimum	6	8	10	72

Addition of 861 Accelerator does not change dry-to-touch or dry-through times but does accelerate cure for service.

Topcoat or recoat time (days) (maximum) °F/°C

	90/32		70/21		50/10	
Product	385	w/861	385	w/861	385	w/861
450HS,	14	3	30	7	42	14
Amershield™	14	3	30	7	42	14

385 or 385PA	
- non-immersion	No maximum – Clean surface required
immersion	6 months – high pressure water wash or roughen surface if exceeded
698HS, 70ESP, 635, 279, 275E, 277E	Apply while 385 is tacky, soft to fingernail

Time before service @ 8 mils (hours) °F/°C

	90/32	70/21	50/10	32/0
385 or 385PA				
immersion				
ambient	24	48	72	240
hot	72	168	336	NR
non-immersion	12	24	36	168
385 or 385PA accelerated @ 1 pt 861/5 gal				
immersion				
ambient	12	24	48	168
hot	36	72	168	NR
non-immersion	6	12	24	96

NR=Not recommended

Safety Precautions

Read each component's material safety data sheet before use. Mixed material has hazards of each component. Safety precautions must be strictly followed during storage, handling and use.

CAUTION – Improper use and handling of this product can be hazardous to health and cause fire or explosion.

Do not use this product without first taking all appropriate safety measures to prevent property damage and injuries. These measures may include, without limitation: implementation of proper ventilation, use of proper lamps, wearing of proper protective clothing and masks, tenting and proper separation of application areas. Consult your supervisor. Proper ventilation and protective measures must be provided during application and drying to keep spray mists and vapor concentrations within safe limits and to protect against toxic hazards. Necessary safety equipment must be used and ventilation requirements carefully observed, especially in confined or enclosed spaces, such as tank interiors and buildings.

This product is to be used by those knowledgeable about proper application methods. Ameron makes no recommendation about the types of safety measures that may need to be adopted because these depend on application environment and space, of which Ameron is unaware and over which it has no control.

If you do not fully understand these warnings and instructions or if you cannot strictly comply with them, do not use the product.

Note: Consult Code of Federal Regulations Title 29, Labor, parts 1910 and 1915 concerning occupational safety and health standards and regulations, as well as any other applicable federal, state and local regulations on safe practices in coating operations.

This product is for professional use only. Not for residential use in California.

Warranty

Ameron warrants its products to be free from defects in material and workmanship. Ameron's sole obligation and Buyer's exclusive remedy in connection with the products shall be limited, at Ameron's option, to either replacement of products not conforming to this Warranty or credit to Buyer's account in the invoiced amount of the nonconforming products. Any claim under this Warranty must be made by Buyer to Ameron in writing within five (5) days of Buyer's discovery of the claimed defect, but in no event later than the expiration of the applicable shelf life, or one year from the delivery date, whichever is earlier. Buyer's failure to notify Ameron of such nonconformance as required herein shall bar buyer from recovery under this Warranty.

Ameron makes no other warranties concerning the product. No other warranties, whether express, implied, or statutory, such as warranties of merchantability or fitness for a particular purpose, shall apply. In no event shall Ameron be liable for consequential or incidental damages.

Any recommendation or suggestion relating to the use of the products made by Ameron, whether in its technical literature, or in response to specific inquiry, or otherwise, is based on data believed to be reliable; however, the products and information are intended for use by Buyers having requisite skill and know-how in the industry, and therefore it is for Buyer to satisfy itself of the suitability of the products for its own particular use and it shall be deemed that Buyer has done so, at its sole discretion and risk. Variation in environment, changes in procedures of use, or extrapolation of data may cause unsatisfactory results.

Limitation of Liability

Ameron's liability on any claim of any kind, including claims based upon Ameron's negligence or strict liability, for any loss or damage arising out of, connected with, or resulting from the use of the products, shall in no case exceed the purchase price allocable to the products or part thereof which give rise to the claim. **In no event shall Ameron be liable for consequential or incidental damages.**

Ameron.
Protective Coatings Systems

201 North Berry Street, Brea, California 92622-1020 • J. F. Kennedylaan 7, 4191 MZ Geldermalsen, The Netherlands

Natural gas piping

Amerlock® 400

High-solids epoxy coating

Application Instructions

Refer to Product Data Sheet for properties and uses.

To obtain the maximum performance, adhere to all application instructions, precautions, conditions and limitations. For conditions outside the requirements or limitations described, contact your Ameron representative.

Surface Preparation

Coating performance is, in general, proportional to the degree of surface preparation. Abrasive blasting is usually the most effective and economical method. When this is impossible or impractical, Amerlock 400 can be applied over mechanically cleaned surfaces.

Amerlock 400 may be used over most types of properly prepared and tightly adhering coatings. A test patch is recommended for use over existing coatings.

Steel – Remove all loose rust, dirt, moisture, grease or other contaminants from surface. Power-tool clean SSPC-SP3 or hand-tool clean SSPC-SP2. For more severe environments, dry abrasive blast SSPC-SP7. Water blasting is also acceptable. For immersion service – dry abrasive blast SSPC-SP10.

Aluminum – Remove oil, grease or soap film with neutral detergent or emulsion cleaner, treat with Alodine® 1200, Alumiprep® or equivalent or blast lightly with fine abrasive.

Galvanizing – Remove oil or soap film with detergent or emulsion cleaner, then use zinc treatment such as Galvaprep® or equivalent or blast lightly with fine abrasive.

Concrete – Acid etching (ASTM D4260) or abrasive blast (ASTM D4259) new concrete cured a minimum of 14 days.

Application Equipment

The following is a guide; suitable equipment from other manufacturers may be used. Changes in pressure, hose and tip size may be needed for proper spray characteristics.

Airless spray – Standard equipment such as Graco Bulldog 30:1 or larger, with a 0.017- to 0.021-inch fluid tip.

Conventional spray – Industrial equipment, such as DeVilbiss MBC or JGA or Binks 18 or 62 spray gun. A moisture and oil trap in the main air supply line, a pressure material pot with mechanical agitator and separate regulators for air and fluid pressure are recommended.

Power mixer – Jiffy Mixer powered by an air or explosion-proof electric motor.

Brush or roller – Additional coats may be required to attain proper thickness.

Environmental Conditions

Product	Air and Surface Temperature
Amerlock 400 or 400 AL	40° to 122°F (4° to 50°C)
Amerlock with 861	20° to 122°F (-6° to 50°C)
Amerlock 400FD cure	20° to 122°F (-6° to 50°C)

Surface temperatures must be at least 5°F (3°C) above dew point to prevent condensation. At freezing temperatures, surface must be free of ice.
See temperature limitations to cure for immersion service.

Pot life (hours)

861 Accelerator Amount	Amerlock /mixed 5 gal	°F/°C 90/32	70/21	50/10	32/0
None	400	1½	2½	4	7
	400AL	3½	5½	10	15
	400FD	1	1½	2½	4
½ pt	400	1	1½	2½	4
	400AL	1	1½	2½	4
1 pt	400	½	1	1½	2

Pot life is the period of time after mixing that a five-gallon unit of material is sprayable when thinned as recommended. Mixture may appear fluid beyond this time, but spraying and film build characteristics may be impaired.

Application Procedure

1. Flush all equipment with thinner or Amercoat® 12 before use.
2. Stir resin using an explosion-proof power mixer to disperse pigments.
3. Add cure to resin. Mix thoroughly until uniformly blended to a workable consistency. For low temperature application, use Amercoat 861 accelerator or 400FD cure. Do not use Amercoat 861 when using Amerlock 400FD cure or with Amerlock white or light colors as color variation may result. Do not exceed the 1 pint Amercoat 861 accelerator per 5 gallon unit recommendation. Do not use 400FD cure with 400AL resin.
4. Do not mix more material than can be used within the expected pot life.
5. For optimum application, material should be from 50° to 90°F (10° to 32°C). Above 122°F (50°C), sagging may occur.
6. Use only Ameron recommended thinners. Above 85°F (29°C) use Amercoat 8, at lower temperatures use Amercoat 65. A small amount of thinner greatly reduces viscosity; excessive thinning will cause running or sagging. Thin cautiously as follows:

Amercoat 8 or 65 thinner	400 and 400FD	400AL
Airless – up to	¼ pt/gal	1½ pt/gal
Conventional – up to	½ pt/gal	1½ pt/gal

Below 50°F additional thinning may be needed and multiple coats required to achieve specified thickness.

7. To minimize orange peel appearance, adjust conventional spray equipment to obtain adequate atomization at lowest air pressure.
8. Apply a wet coat in even, parallel passes with 50 percent overlap to avoid holidays, bare areas and pinholes. If required, cross spray at right angles.
9. When applying Amerlock 400 directly over inorganic zincs or zinc-rich primers, a mist coat/full coat technique may be required to minimize bubbling. This will depend on the age of the Dimetcote®, surface roughness and conditions during curing.

Note – Do not use Amerlock 400AL on water damp surfaces

10. Ventilate confined areas with clean air between coats and while curing the final coat. Prevent moisture condensation on the surface between coats.

11. Repair damaged areas by brush or spray.

12. Clean equipment with thinner or Amercoat 12 immediately after use.

Drying time (ASTM D1640) (hours)

861 Amt	Amerlock /mixed 5 gal	120/49	90/32	70/21	50/10	32/0	20/-6
				touch °F/°C			
None	400	1½	4½	9	28	96	NR
	400AL	1	4	12	36	96	NR
	400FD cure	½	1	2	8	24	48
½ pt	400	1½	3	5	24	72	120
	400AL	1	1½	2½	5	10	24
1 pt	400	1	2	4	15	48	96
				through			
None	400	6	12	20	40	140	NR
	400AL	1½	7½	24	72	216	NR
	400FD cure	1½	2½	4½	13	38	96
½ pt	400	3	6	10	30	96	180
	400AL	2	4	9	24	48	120
1 pt	400	2½	5	9	24	72	160
			Cure for immersion (days)				
None	400	2	4	7	21	NR	NR
	400AL	2	4	7	21	NR	NR
	400FD cure	1	2	3	7	21	NR
½ pt	400AL	1	2	3	7	21	NR
1 pt	400	1	2	3	7	21	NR

Amercoat 861 Accelerator will slightly discolor Amerlock 400 white and other Amerlock light colors. Do not use 861 Accelerator with 400FD cure.

NR = Not recommended

Recoat/Topcoat time minimum (hours)	°F/°C 90/32	70/21	50/10
400	8	16	30
400 with 1 pt 861	4	7	16
400FD	2	3½	10
400AL	3	12	48
400AL with ½ pt 861	3	5	12

Recoat/Topcoat time @ 70°F (21°C)

System	Maximum time
400/400	3 months
400 with 861/400	1 month
400FD/400FD	2 weeks
400/Amershield or 450HS	1 month
400FD/Amershield or 450HS	7 days
400 with 861/Amershield or 450HS	2 weeks

Note: If maximum time is exceeded, roughen surface. For topcoats (finish coats) not listed, see Product Data sheet for specific topcoat time limitations.

Safety Precautions

Read each component's material safety data sheet before use. Mixed material has hazards of each component. Safety precautions must be strictly followed during storage, handling and use.

CAUTION – Improper use and handling of this product can be hazardous to health and cause fire or explosion.

Do not use this product without first taking all appropriate safety measures to prevent property damage and injuries. These measures may include, without limitation: implementation of proper ventilation, use of proper lamps, wearing of proper protective clothing and masks, tenting and proper separation of application areas. Consult your supervisor. Proper ventilation and protective measures must be provided during application and drying to keep solvent vapor concentrations within safe limits and to protect against toxic hazards. Necessary safety equipment must be used and ventilation requirements carefully observed, especially in confined or enclosed spaces, such as tank interiors and buildings.

This product is to be used by those knowledgeable about proper application methods. Ameron makes no recommendation about the types of safety measures that may need to be adopted because these depend on application and space, of which Ameron is unaware and over which it has no control.

If you do not fully understand the warnings and instructions or if you cannot strictly comply with them, do not use the product.

Note: Consult Code of Federal Regulations Title 29, Labor, parts 1910 and 1915 concerning occupational safety and health standards and regulations, as well as any other applicable federal, state and local regulations on safe practices in coating operations.

This product is for professional use only. Not for residential use in California.

Warranty

Ameron warrants its products to be free from defects in material and workmanship. Ameron's sole obligation and Buyer's exclusive remedy in connection with the products shall be limited, at Ameron's option, to either replacement of products not conforming to this Warranty or credit to Buyer's account in the invoiced amount of the nonconforming products. Any claim under this Warranty must be made by Buyer to Ameron in writing within five (5) days of Buyer's discovery of the claimed defect, but in no event later than the expiration of the applicable shelf life, or one year from the delivery date, whichever is earlier. Buyer's failure to notify Ameron of such nonconformance as required herein shall bar Buyer from recovery under this Warranty.

Ameron makes no other warranties concerning the product. No other warranties, whether expressed, implied, or statutory, such as warranties of merchantability or fitness for a particular purpose, shall apply. In no event shall Ameron be liable for consequential or incidental damages.

Any recommendation or suggestion relating to use of the products made by Ameron, whether in its technical literature, or in response to specific inquiry, or otherwise, is based on data believed to be reliable; however, the products and information are intended for use by Buyers having requisite skill and know-how in the industry, and therefore it is for Buyer to satisfy itself of the suitability of the products for its own particular use and it shall be deemed that Buyer has done so, at its sole discretion and risk. Variation in environment, changes in procedures of use, or extrapolation of data may cause unsatisfactory results.

Limitation of Liability

Ameron's liability on any claim of any kind, including claims based upon Ameron's negligence or strict liability, for any loss or damage arising out of, connected with, or resulting from the use of the products, shall in no case exceed the purchase price allocable to the products or part thereof which give rise to the claim. **In no event shall Ameron be liable for consequential or incidental damages.**

Ameron.

Protective Coatings Systems

201 North Berry Street, Brea, California 92622-1020 • J. F. Kennedylaan 7, 4191 MZ Geldermalsen, The Netherlands

Ameron®

Amerlock® 400

High-solids epoxy coating

Product Data

- VOC compliant
- High-performance general maintenance coating for new or old steel
- Cures through wide temperature range
- Self-priming topcoat over most existing coatings
- Can be overcoated with wide range of topcoats
- Compatible with prepared damp surfaces
- Compatible with adherent rust remaining on prepared surfaces
- 5 mils or more in a single coat
- Resists high humidity and moisture

Amerlock's low solvent level meets VOC requirements, reduces the chances for film pinholing and solvent entrapment at the substrate-coating interface, often a major cause of coating failure with conventional epoxies and lower solids systems.

Amerlock 400 is available in a variety of colors, including aluminum, and therefore does not require a topcoat. For extended weatherability or special uses, a topcoat may be desired.

Typical Uses

Amerlock 400 is used in those areas where blasting is impractical or impossible. As a maintenance coating, Amerlock 400 protects steel structures in industrial facilities, bridges, tank exteriors, marine weathering, offshore, oil tanks, piping, roofs, water towers and other exposures. Amerlock 400 has good chemical resistance to splash/spillage, fumes and immersion in neutral, fresh and salt water (see resistance table). Contact your Ameron representative for specific information.

Typical Properties

Physical

Abrasion resistance (ASTM D4060)	
1 kg load/1000 cycles	weight loss
CS-17 wheel	102 mg
Impact resistance (ASTM D2794)	
Direct	24 in · lb
Reverse	6 in · lb
Moisture vapor transmission (ASTM F1249)	4.49 g/m²
Adhesion (ASTM D4541)	900 psi

Performance

Salt spray (ASTM B117) 3000 hours	
Face blistering	None
Humidity (ASTM D2247) 750 hours	
Face corrosion, blistering	None
Immersion (NACE TM-01-69) fresh water 1 year	
blistering	None

Physical Data

Finish	Semigloss
Color	Standard, Rapid Response, custom colors and aluminum

White and light colors may show yellowing on aging. Do not use Amercoat 861 with white or light colors or with 400FD cure. With white and light colors, 400FD cure will cause yellowing.
Yellow, red and orange colors will fade faster than other colors due to the replacement of lead-based pigments with lead-free pigments in these colors

Components	2	
Curing mechanism	Solvent release and chemical reaction between components	
Volume solids (ASTM D2697 modified)		
400	83% ± 3%	
400AL	88% ± 3%	
Dry film thickness (per coat)	5-8 mils (125-200 microns)	
Coats	1 or 2	
Theoretical coverage	ft²/gal	m²/L
1 mil (25 microns)		
400	1331	32.6
400AL	1412	34.7
5 mils (125 microns)		
400	266	6.5
400AL	282	6.9
VOC	lb/gal	g/L
400 mixed	1.4	168
mixed/thinned (1/2 pt/gal)	1.7	204
400AL mixed	1.0	120
mixed/thinned (1 1/2 pt/gal)	2.0	240
400FD mixed	1.2	144
mixed/thinned (1/2 pt/gal)	1.6	192
Temperature resistance, dry	°F	°C
continuous	200	93
intermittent	350	177
Flash point (SETA)	°F	°C
400 resin	131	55
400 cure	85	29
400FD cure	87	30
400AL resin	110	43
400AL cure	116	47
Amercoat® 8	67	19
Amercoat 65	78	25
Amercoat 12	0	-18

Qualifications

USDA – Incidental food contact
NFPA – Class A

NSF Standard 61 – For use in drinking water;
Amerlock 400 and 400FD – White, Ivory and RT-1805 Blue,
Certain restrictions do apply.

Chemical Resistance Guide

Environment	Immersion		Splash and Spillage		Fumes and Weather	
	400	400AL	400	400AL	400	400AL
Acidic	*	*	F	F	G	G
Alkaline	*	*	E	G	E	E
Solvents	*	*	G	G	E	E
Salt water	E	E	E	E	E	E
Water	E	E	E	E	E	E

F-Fair G-Good E-Excellent

**Contact your Ameron representative.*

This table is only a guide to show typical resistances of Amerlock 400 and 400AL. For specific recommendations, contact your Ameron representative representative for your particular corrosion protection needs.

Systems using Amerlock 400 or 400AL

1st coat	2nd Coat***	3rd coat***
400	None	None
400	450HS	None
	Amershield™	None
400**	400	None
Dimetcote® 9, 9FT or 21-9	400	None
Dimetcote 9, 9FT or 21-9	400	450HS

***Water immersion.*

****For color contrast when 2 coats of 400AL are used, 400AL red can be used as first coat.*

Recoat/Topcoat time minimum (hours)	90/32 °F/°C	70/21 °F/°C	50/10 °F/°C
400	8	16	30
400 with 1 pt 861	4	7	16
400FD	2	$3^1/_2$	10
400AL	3	12	48
400AL with $^1/_2$ pt 861	3	5	12

Recoat/Topcoat time @ 70°F (21°C)

System	Maximum time
400/400	3 months
400 with 861/400	1 month
400FD/400FD	2 weeks
400/Amershield or 450HS	1 month
400FD/Amershield or 450HS	7 days
400 with 861/Amershield or 450HS	2 weeks

Note: If maximum time is exceeded, roughen surface. For topcoats (finish coats) not listed, see Product Data sheet for specific topcoat time limitations.

Application Data Summary

See Application Instructions for complete information on surface preparation, environmental conditions, application procedures and equipment. To obtain maximum performance, apply as recommended. Adhere to all safety precautions during storage, handling, application and drying periods.

Surface Preparation

Coating performance is, in general, proportional to the degree of surface preparation. Abrasive blasting is usually the most effective and economical method. When this is impossible or impractical, Amerlock 400 can be applied over mechanically cleaned surfaces. All surfaces must be clean, dry and free of all contaminants, including salt deposits.

Application Data

Applied over	Steel, concrete, aluminum, galvanizing
Surface preparation	
Steel	SSPC-SP2, 3, 7 or 10
Concrete	ASTM D4259 or 4260
Aluminum	Alodine®, Alumiprep® or light abrasive blast
Galvanizing	Galvaprep® or light abrasive blast
Method	Airless or conventional spray. Brush or roller may require additional coats.
Mixing ratio (by volume)	1 part resin to 1 part cure

Pot life (hours) 861 Accelerator Amount	Amerlock /mixed 5 gal	90/32 °F/°C	70/21 °F/°C	50/10 °F/°C	32/0 °F/°C
None	400	$1^1/_2$	$2^1/_2$	4	7
	400AL	$3^1/_2$	$5^1/_2$	10	15
	400FD	1	$1^1/_2$	$2^1/_2$	4
$^1/_2$ pt	400	1	$1^1/_2$	$2^1/_2$	4
	400AL	1	$1^1/_2$	$2^1/_2$	4
1 pt	400	$^1/_2$	1	$1^1/_2$	2

Pot life is the period of time after mixing that a five-gallon unit of material is sprayable when thinned as recommended. Mixture may appear fluid beyond this time, but spraying and film build characteristics may be impaired.

Environmental conditions

Product	Air and Surface Temperature
Amerlock 400 or 400 AL	40° to 122°F (4° to 50°C)
Amerlock with 861	20° to 122°F (-6° to 50°C)
Amerlock 400FD cure	20° to 122°F (-6° to 50°C)

Surface temperatures must be at least 5°F (3°C) above dew point to prevent condensation. At freezing temperatures, surface must be free of ice.

Do not use Amerlock 400AL on water damp surfaces. Do not use 400FD cure with 400AL resin.

Drying time (ASTM D1640) (hours)

861 Amt	Amerlock /mixed 5 gal	120/49 °F/°C	90/32 °F/°C	70/21 °F/°C	50/10 °F/°C	32/0 °F/°C	20/-6 °F/°C
		touch					
None	400	$1^1/_2$	$4^1/_2$	9	28	96	NR
	400AL	1	4	12	36	96	NR
	400FD cure	$^1/_2$	1	2	8	24	48
$^1/_2$ pt	400	$1^1/_2$	3	5	24	72	120
	400AL	1	$1^1/_2$	$2^1/_2$	5	10	24
1 pt	400	1	2	4	15	48	96
		through					
None	400	6	12	20	40	140	NR
	400AL	$1^1/_2$	$7^1/_2$	24	72	216	NR
	400FD cure	$1^1/_2$	$2^1/_2$	$4^1/_2$	13	38	96
$^1/_2$ pt	400	3	6	10	30	96	180
	400AL	2	4	9	24	48	120
1 pt	400	$2^1/_2$	5	9	24	72	160
		Cure for immersion (days)					
None	400	2	4	7	21	NR	NR
	400AL	2	4	7	21	NR	NR
	400FD cure	1	2	3	7	21	NR
$^1/_2$ pt	400AL	1	2	3	7	21	NR
1 pt	400	1	2	3	7	21	NR

Amercoat 861 Accelerator will slightly discolor Amerlock 400 white and other Amerlock light colors. Do not use 861 Accelerator with 400FD cure.

NR = Not recommended

Safety Precautions

Read each component's material safety data sheet before use. Mixed material has hazards of both components. Safety precautions must be strictly followed during storage, handling, and use.

This product is for industrial use only. Not for residential use in California.

Warranty

Ameron warrants its products to be free from defects in material and workmanship. Ameron's sole obligation and Buyer's exclusive remedy in connection with the products shall be limited, at Ameron's option, to either replacement of products not conforming to this Warranty or credit to Buyer's account in the invoiced amount of the nonconforming products. Any claim under this Warranty must be made by Buyer to Ameron in writing within five (5) days of Buyer's discovery of the claimed defect, but in no event later than the expiration of the applicable shelf life, or one year from the delivery date, whichever is earlier. Buyer's failure to notify Ameron of such nonconformance as required herein shall bar Buyer from recovery under this Warranty.

Ameron makes no other warranties concerning the product. No other warranties, whether express, implied, or statutory, such as warranties of merchantability or fitness for a particular purpose, shall apply. In no event shall Ameron be liable for consequential or incidental damages.

Any recommendation or suggestion relating to the use of the products made by Ameron, whether in its technical literature, or in response to specific inquiry, or otherwise, is based on data believed to be reliable; however, the products and information are intended for use by Buyers having requisite skill and know-how in the industry, and therefore it is for Buyer to satisfy itself of the suitability of the products for its own particular use and it shall be deemed that Buyer has done so, at its sole discretion and risk. Variation in environment, changes in procedures of use, or extrapolation of data may cause unsatisfactory results.

Thinner	Amercoat 8 or 65
Equipment cleaner	Thinner or Amercoat 12

Shipping Data

Packaging unit	2 gal	5 gal
cure	1-gal can	2.5-gal can
resin	1-gal can	2.5-gal can
Shipping weight (approx)	lbs	kg
2-gal unit		
400 cure	12.5	5.7
400FD cure	12.2	5.5
400 resin	13.7	6.2
400AL cure	12.1	5.5
400AL resin	11.0	5.0
5-gal unit		
400 cure	31.8	14.4
400FD cure	31.2	14.2
400 resin	35.0	15.9
400AL cure	30.9	14.0
400AL resin	28.3	12.8

Shelf life when stored indoors at 40° to 100°F (4° to 38°C)
resin and cure — 1 year from shipment date.

Numerical values are subject to normal manufacturing tolerances, color and testing variances. Allow for application losses and surface irregularities.

This mixed product is photochemically reactive as defined by the South Coast Air Quality Management District's Rule 102 or equivalent regulations.

Limitation of Liability

Ameron's liability on any claim of any kind, including claims based upon Ameron's negligence or strict liability, for any loss or damage arising out of, connected with, or resulting from the use of the products, shall in no case exceed the purchase price allocable to the products or part thereof which give rise to the claim. **In no event shall Ameron be liable for consequential or incidental damages.**

OPERATIONS AND MAINTENANCE MANUAL
MULTIPHASE RECOVERY SYSTEM
FUEL FARM 216
NAS CORPUS CHRISTI, TEXAS

ATTACHMENT 10

NEPCCO GROUNDWATER REMEDIATION SYSTEM MANUAL

NEPCCO
A Division of ZENTOX Corporation

2140 N.E. 36th Ave., Ocala, FL 34470
800 277-3279 • Fax 352 867-1320
EM nepcco@zentox.com

Welcome!

Thank you for choosing NEPCCO as your equipment supplier. At NEPCCO, we are committed to developing outstanding products that are easy to use; our goal is to significantly enhance your productivity.

We are equally committed to providing you with the highest standard of service and support after you have purchased a NEPCCO product. We believe that the quality of our support and customer service is as important as the quality of our products.

Please don't hesitate to let me know how we are doing. It is through your comments and suggestions that we learn how we can continue to improve our products and services. Our toll free Customer Support No. is 800-277-3279.

We value you as a customer, and we want you to be as pleased with your NEPCCO product as we are in bringing it to you.

Sincerely,

Chris Dobbs
Quality Assurance Manager

UNLOADING PROCEDURE FOR NEPCCO SKID MOUNTED EQUIPMENT

BEFORE ATTEMPTING TO UNLOAD ANY EQUIPMENT, ENSURE THAT NO DAMAGE HAS OCCURRED DURING SHIPMENT.

FORKLIFT

NOTE: NEPCCO DOES NOT RECOMMEND THAT SYSTEMS OF EXCESSIVE WEIGHT OR SIZE (LARGER THAN 6' X 12') OR CONTAINERIZED SYSTEMS (BUILDINGS) BE UNLOADED WITH A FORKLIFT. FORKLIFT SLOTS ON 8' X 16' AND 10' X 20' SKIDS ARE INTENDED ONLY FOR MOVING THE SKID AT THE NEPCCO FACTORY.

1) Verify that all shipping restraints have been removed.

2) Allow forks to enter the fork slots as far as possible.

3) Lift the skid and tilt as necessary to clear trailer bed.

4) Back away from trailer until the unit is clear, then lower the unit for transportation.

5) Set skid into place and withdraw forks from fork slots.

CRANE

1) Verify that all shipping restraints have been removed.

2) Containerized units (buildings), as well as many skid-mounted systems, require the use of cable spreader bars when unloading with a crane. The distance between the spreader bar eyes should be a minimum of 12'.

START UP PROCEDURES

ENGINEERING DRAWINGS

COMPONENTS LISTS

INSTALLATION & START UP PROCEDURES
NEPCCO #1028

1) Read the entire manual before operating this system. The manual contains specific information about the equipment on this system.

2) Install skid on a level concrete pad with a minimum perimeter of 6" around the skid base. Anchor bolts or clip fasteners are recommended to secure the skid to the pad. Place and secure the oil/water separator and the storage tanks. THE SYSTEM MUST BE LEVEL TO OPERATE PROPERLY.

3) Connect the influent and effluent lines to system piping as per process and instrumentation diagram numbered 1028-2-01.

4) Ensure all valves are open/closed per the process and instrumentation diagram, and close all petcocks and sample ports.

5) Mount the control panel in a suitable non-hazardous location.

6) All electrical work should be performed by a qualified electrician in accordance with the latest edition of the National Electric Code, local codes and regulations. This system requires 240 VAC single phase power with neutral and ground. NOTE: CONNECT AC POWER IN ACCORDANCE WITH NEC ARTICLE 384-3 WITH HIGH VOLTAGE LEG ON B PHASE. Short circuit protection should be provided according to the total load summary of the system. Refer to the Ladder Logic/Power Wiring Diagrams for electrical integration of the system Integrate the telemetry unit with the telephone network.

7) Turn all control panel switches to the "OFF" position and ensure that the main power disconnect (supplied by others on site) is in the "OFF" position.

8) Place all circuit breakers inside FP-1 in the "ON" position and close the front panel.

9) Turn on power at the main power disconnect.

10) Place the system power switch in the "RUN" position.

11) Turn the switches for the transfer pumps and the motorized valves to the "AUTO" position. Refer to the Control Logic description in this section for conditions of automatic operation.

CONTROL LOGIC

6/2/97

PROJECT NUMBER: 1028

PROJECT NAME: APPLIED EARTH SCIENCE

OPERATOR/INDICATOR	DESCRIPTION
SYSTEM SWITCH "OFF"	RESETS SYSTEM (FAILSAFE, TIMERS). INITIATES 1 MIN. DELAY TO LOCKOUT OXIDIZER ALARM INPUT. INITIATES 30 MIN. DIALOUT DELAY.
SYSTEM SWITCH "RUN"	STARTS SYSTEM. SYSTEM WILL OPERATE ACCORDING TO FOLLOWING INPUT AND PROGRAM CONDITIONS FOUND IN THE PLC.
SYSTEM "RUN" LAMP	ON WHEN SYSTEM SWITCH IS IN "RUN" POSITON. FLASHES WHEN SYSTEM SWITCH IS IN "RUN" POS. AND OXIDIZER IS STANDING BY(BELOW 1400 °F).
SYSTEM "OFF" LAMP	ON WHEN SYSTEM SWITCH IS IN "OFF" POSITON.
VACUUM PUMP VP-1 SWITCH "MANUAL"	TURNS ON VACUUM PUMP VP-1.
VACUUM PUMP VP-1 SWITCH "AUTO"	TURNS ON VACUUM PUMP VP-1. IF FAILSAFE CONDITIONS ARE FOUND, VP-1 WILL BE SHUT DOWN. WILL NOT RUN IF OXIDIZER TEMP. IS BELOW 1400 °F.
VACUUM PUMP VP-1 "ON" LAMP	ON WHEN VACUUM PUMP VP-1 IS RUNNING.
TRANSFER PUMP P-1 SWITCH "MANUAL"	TURNS ON TRANSFER PUMP P-1.
TRANSFER PUMP P-1 SWITCH "AUTO"	TRANSFER PUMP P-1 WILL OPERATE ACCORDING TO RESPONSES LISTED AFTER LSH-1 AND LSL-1. IF FAILSAFE CONDITIONS ARE FOUND, P-1 WILL BE SHUT DOWN. WILL NOT RUN IF OXIDIZER TEMP. IS BELOW 1400 °F.
TRANSFER PUMP P-1 "ON" LAMP	ON WHEN TRANSFER PUMP P-1 IS RUNNING.
TRANSFER PUMP P-2 SWITCH "MANUAL"	TURNS ON TRANSFER PUMP P-2.
TRANSFER PUMP P-2 SWITCH "AUTO"	TRANSFER PUMP P-2 WILL OPERATE ACCORDING TO RESPONSES LISTED AFTER LSH-3 AND LSL-3. IF FAILSAFE CONDITIONS ARE FOUND, P-1 WILL BE SHUT DOWN. WILL NOT RUN IF OXIDIZER TEMP. IS BELOW 1400 °F.
TRANSFER PUMP P-2 "ON" LAMP	ON WHEN TRANSFER PUMP P-2 IS RUNNING.
LEVEL SWITCH LOW #1/LSL-1	TURNS OFF TRANSFER PUMP P-1 AND CLOSES SOLENOID VALVE SV-1.
LEVEL SWITCH HIGH #1/LSH-1	TURNS ON TRANSFER PUMP P-1.
LEVEL SWITCH HIGH #2/LSH-2	OPENS SOLENOID VALVE SV-1.
LEVEL SWITCH LOW #3/LSL-3	TURNS OFF TRANSFER PUMP P-2.

OPERATOR/INDICATOR	DESCRIPTION
LEVEL SWITCH HIGH #3/LSH-3	TURNS ON TRANSFER PUMP P-2
LEVEL SWITCH LOW#4/LSL-4	CLOSES MOTORIZED VALVE MV-6
LEVEL SWITCH HIGH #4/LSH-4	OPENS MOTORIZED VALVE MV-6
OXIDIZER AUTO INPUT	SHUTS DOWN VACUUM PUMP, TRANSFER PUMS, STOPS MOTORIZED VALVE CYCLE TIMER AND CLOSES SOLENOID VALVES WHILE OXIDIZER TEMP IS LESS THAN 1400°F
LEVEL SWITCH LOW #5/LSL-5	OPENS SOLENDOID VALVE SV-2 AND SV3. CLOSES SV-4.
LEVEL SWITCH HIGH #5/LSH-5	CLOSES SOLENOID VALVE SV-2 AND SV-3. OPENS SV-4.
TEMPERATURE SWITCH	OPENS SOLENOID VALVE SV-2 AND SV-3 AND CLOSES SV-4 WHEN TANK T-2 WATER TEMP. IS ABOVE 125°F. CLOSES SOLENOID VALVE SV-2 AND SV-3 AND OPENS SV-4 WHEN TANK T-2 WATER TEMP. IS BELOW 115°F.
MOTORIZED VALVE MV-1 SWITCH "MANUAL"	OPENS MOTORIZED VALVE MV-1
MOTORIZED VALVE MV-1 SWITCH "AUTO"	AFTER MOTORIZED VALVE MV-5 CLOSES, MV-1 WILL OPEN FOR 3.0 HOURS. IF FAILSAFE CONDITIONS ARE FOUND, MV-1 WILL BE CLOSED. WHEN OXIDIZER IS BELOW 1400°F BALL VALVE CYCLE TIMER WILL BE STOPPED AND RETAIN VALUE.
MOTORIZED VALVE MV-2 SWITCH "MANUAL"	OPENS MOTORIZED VALVE MV-2
MOTORIZED VALVE MV-2 SWITCH "AUTO"	AFTER MOTORIZED VALVE MV-1 CLOSES, MV-2 WILL OPEN FOR 2.0 HOURS. IF FAILSAFE CONDITIONS ARE FOUND, MV-2 WILL BE CLOSED. WHEN OXIDIZER IS BELOW 1400°F BALL VALVE CYCLE TIMER WILL BE STOPPED AND RETAIN VALUE.
MOTORIZED VALVE MV-3 SWITCH "MANUAL"	OPENS MOTORIZED VALVE MV-3
MOTORIZED VALVE MV-3 SWITCH "AUTO"	AFTER MOTORIZED VALVE MV-2 CLOSES, MV-3 WILL OPEN FOR 1.5 HOURS. IF FAILSAFE CONDITIONS ARE FOUND,MV-3 WILL BE CLOSED. WHEN OXIDIZER IS BELOW 1400°F BALL VALVE CYCLE TIMER WILL BE STOPPED AND RETAIN VALUE.
MOTORIZED VALVE MV-4 SWITCH "MANUAL"	OPENS MOTORIZED VALVE MV-4

CONTROL LOGIC

6/2/97

PROJECT NUMBER: 1028

PROJECT NAME: APPLIED EARTH SCIENCE

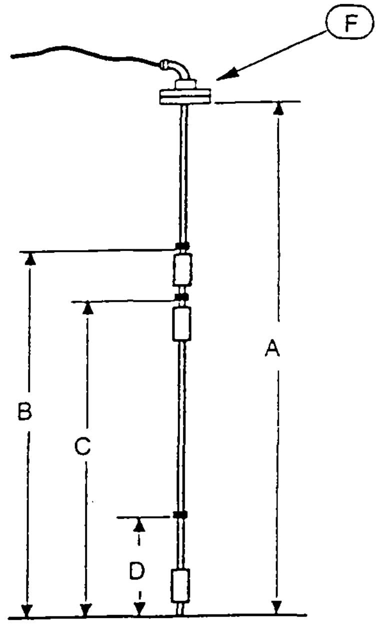
OPERATOR/INDICATOR	DESCRIPTION
MOTORIZED VALVE MV-4 SWITCH "AUTO"	AFTER MOTORIZED VALVE MV-3 CLOSES, MV-4 WILL OPEN FOR 0.75 HOUR. IF FAILSAFE CONDITIONS ARE FOUND, MV-4 WILL BE CLOSED. WHEN OXIDIZER IS BELOW 1400 °F BALL VALVE CYCLE TIMER WILL BE STOPPED AND RETAIN VALUE.
MOTORIZED VALVE MV-5 SWITCH "MANUAL"	OPENS MOTORIZED VALVE MV-5
MOTORIZED VALVE MV-5 SWITCH "AUTO"	AFTER MOTORIZED VALVE MV-4 CLOSES, MV-5 WILL OPEN FOR 0.75 HOUR. IF FAILSAFE CONDITIONS ARE FOUND, MV-5 WILL BE CLOSED. WHEN OXIDIZER IS BELOW 1400 °F BALL VALVE CYCLE TIMER WILL BE STOPPED AND RETAIN VALUE.
MOTORIZED VALVE MV-6 SWITCH "MANUAL"	OPENS ON MOTORIZED VALVE MV-6
MOTORIZED VALVE MV-6 SWITCH "AUTO"	MOTORIZED VALVE MV-6 WILL OPERATE ACCORDING TO RESPONSES LISTED AFTER LSH-4 AND LSL-4. IF FAILSAFE CONDITIONS ARE FOUND, MV-6 WILL BE CLOSED.

CONTROL LOGIC

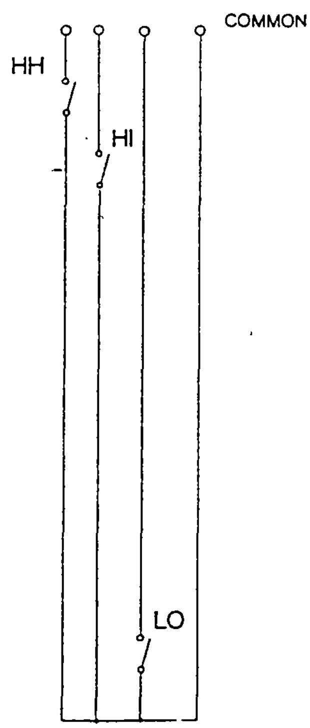
PROJECT NUMBER: 1028

PROJECT NAME: APPLIED EARTH SCIENCE

OPERATOR/INDICATOR	DESCRIPTION
ALARMS:	
LEVEL SWITCH HIGH-HIGH #1/LSHH-1 OXIDIZER	SHUTS DOWN VACUUM PUMP, TRANSFER PUMPS, OXIDIZER, CLOSES MOTORIZED VALVES AND SOLENOID VALVES UNTIL MANUALLY RESET. INITIATES ALARM CONDITION DIALOUT
LEVEL SWITCH HIGH-HIGH #1/LSHH-1 OXIDIZER ALARM LAMP	FLASHES (SLOW) WHEN TANK T-1 LEVEL HIGH-HIGH ALARM CONDITION EXISTS. FLASHES (FAST) WHEN OXIDIZER ALARM CONDITION EXISTS.
LEVEL SWITCH HIGH-HIGH #2/LSHH-2	SHUTS DOWN VACUUM PUMP, TRANSFER PUMPS, OXIDIZER, CLOSES MOTORIZED VALVES AND SOLENOID VALVES UNTIL MANUALLY RESET. INITIATES ALARM CONDITION DIALOUT
LEVEL SWITCH HIGH-HIGH #2/LSHH-2 ALARM LAMP	FLASHES (SLOW) WHEN TANK T-2 LEVEL HIGH-HIGH ALARM CONDITION EXISTS. FLASHES (FAST) WHEN LRV OVERLOAD BREAKER TRIPS.
LEVEL SWITCH HIGH-HIGH #3/LSHH-3	SHUTS DOWN VACUUM PUMP, TRANSFER PUMPS, OXIDIZER, CLOSES MOTORIZED VALVES AND SOLENOID VALVES UNTIL MANUALLY RESET. INITIATES ALARM CONDITION DIALOUT
LEVEL SWITCH HIGH-HIGH #3/LSHH-3 ALARM LAMP	FLASHES (SLOW) WHEN TANK T-4 LEVEL HIGH-HIGH ALARM CONDITION EXISTS
LEVEL SWITCH HIGH-HIGH #4/LSHH-4	SHUTS DOWN VACUUM PUMP, TRANSFER PUMPS, OXIDIZER, CLOSES MOTORIZED VALVES AND SOLENOID VALVES UNTIL MANUALLY RESET. INITIATES ALARM CONDITION DIALOUT
LEVEL SWITCH HIGH-HIGH #4/LSHH-4 ALARM LAMP	FLASHES (SLOW) WHEN TANK T-5 LEVEL HIGH-HIGH ALARM CONDITION EXISTS
LEVEL SWITCH HIGH-HIGH #5/LSHH-5 & LEVEL SWITCH HIGH-HIGH #6/LSHH-6 (SUMP)	SHUTS DOWN VACUUM PUMP, TRANSFER PUMPS, OXIDIZER, CLOSES MOTORIZED VALVES AND SOLENOID VALVES UNTIL MANUALLY RESET. INITIATES ALARM CONDITION DIALOUT
LEVEL SWITCH HIGH-HIGH #5/LSHH-5 & LEVEL SWITCH HIGH-HIGH #6/LSHH-6 ALARM LAMP	FLASHES (SLOW) WHEN TANK T-6 LEVEL HIGH-HIGH OR SUMP LEVEL HIGH-HIGH ALARM CONDITION EXISTS
WARNING BEACON	FLASHES WHEN ANY ALARM CONDITION EXISTS



PLAN VIEW



SCHEMATIC

☐ MLP STANDARD SUMP OP-5
PN 50-0095

A= 28" OVERALL LENGTH
B= 20" HI HI
C= 14" HI
D= 4" LO

☐ MLP OP-12, OP-20
PN 50-0095-03

A= 40" OVERALL LENGTH
B= 32" HI HI
C= 25" HI
D= 4" LO

☐ MLP MC - 20
PN 50-0095-04

A= 40" OVERALL LENGTH
B= 20" HI HI
C= 10" HI
D= 4" LO

☐ MLP LOWPROFILE SUMP
PN 50-0095-05

A= 21" OVERALL LENGTH
B= 16" HI HI
C= 10" HI
D= 4" LO

☒ MLP SPECIAL APPLICATION

A= 46 " OVERALL LENGTH
B= 40 " HI HI
C= 36 " HI
D= 4 " LO

☐ MLP OP-50

A= 56" OVERALL LENGTH
B= 36" HI HI
C=29" HI
D= 6" LO

NOTES:

A.) ALL REED SWITCHES NORMALLY OPEN (FLOATS DOWN)

B.) HI-HI = RED WIRE

C.) HI = YELLOW WIRE

D.) LO = BLACK WIRE

E.) COMMON = GREEN WIRE

F.) DO NOT PAINT DRUM BUNG

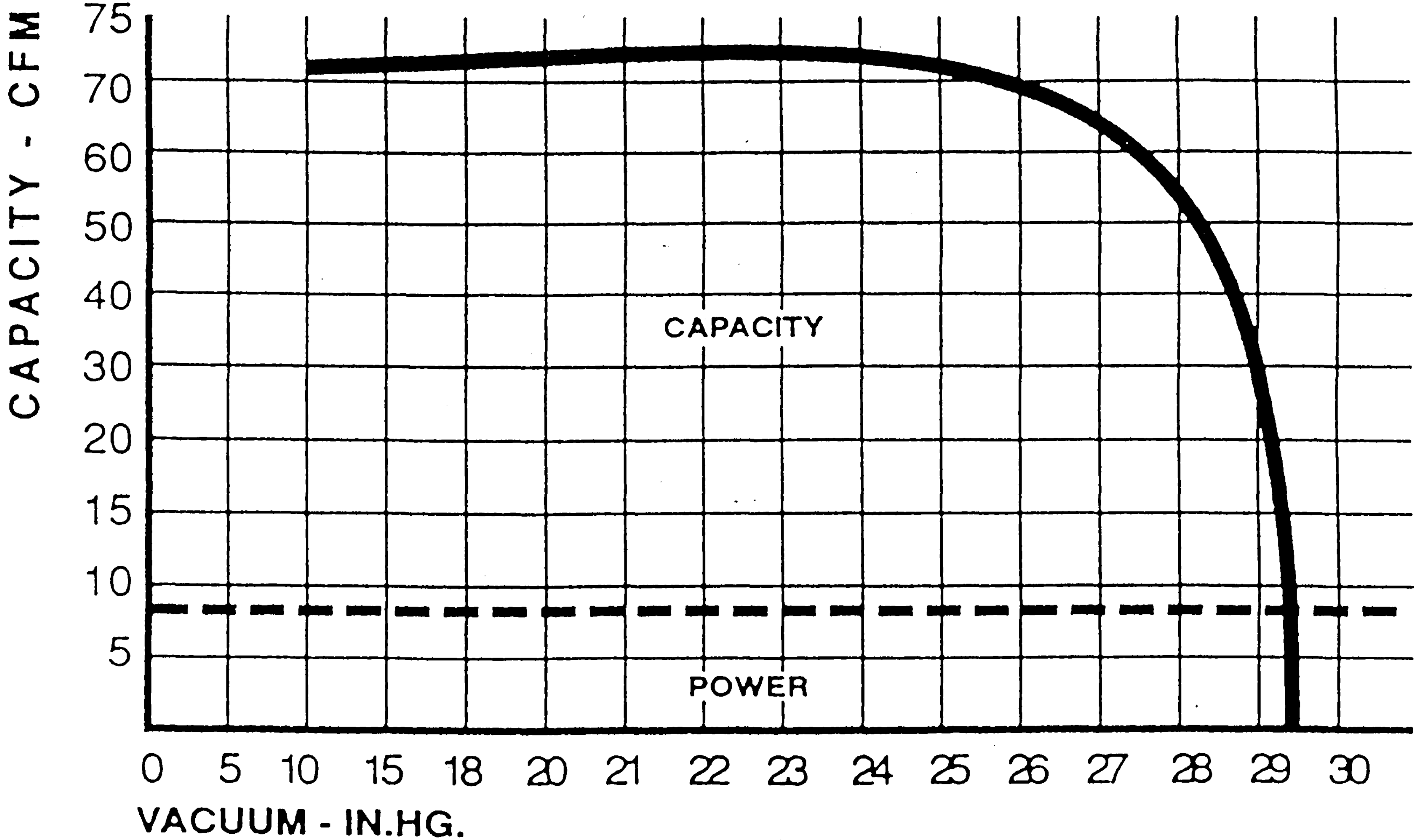
NOTE:

NEPCCO Multilevel Probes are Intended for 5VDC use ONLY !

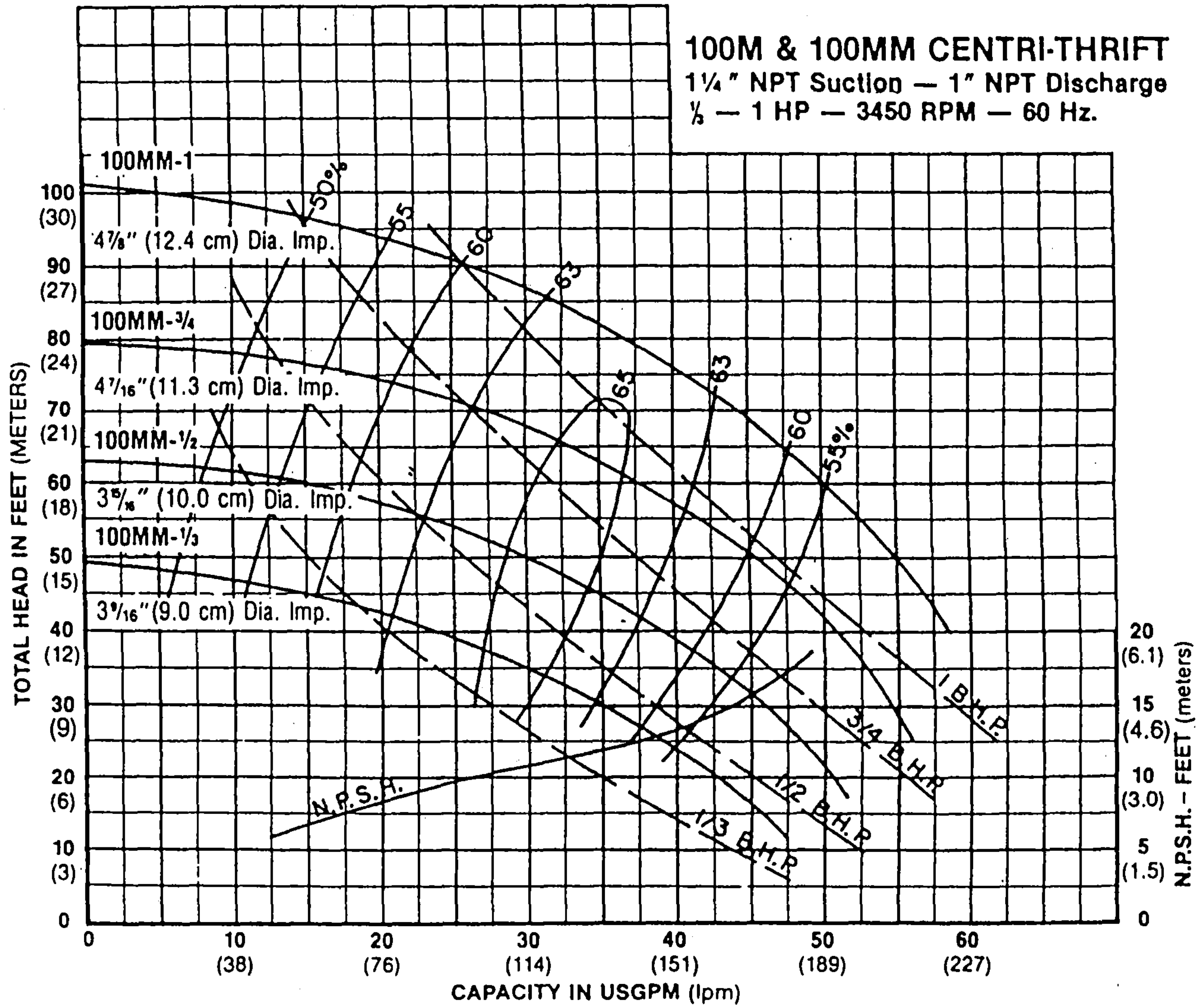
Drawn by WC	Date 01/11/95	Title MULTILEVEL PROBE 550 GAL. TANK (T-5)	NEPCCO
Chkd by	Rev A		
Approved Eng.	Approved QA	Drawing No ES-4-020-090	Project No 1028
		Customer E.A.S.	Customer No. 2430561601

MODEL A 75

1750 RPM



Myers® pump performance curves



COMPONENT LIST

PROJECT NAME: APPLIED EARTH SCIENCE — 12/2/96
PROJECT NUMBER: 1028

ITEM	NO. REQ.	P&ID LABEL	DESCRIPTION AND SPECIFICATIONS	PART NUMBER	SERIAL NUMBER
			CONTROLS (NEMA 4) CONTINUED		
45	1		LEGEND PLATE, RED FIELD/WHITE LETTERS "LSHH-4"	9001-KN799BP	
46	1		LEGEND PLATE, RED FIELD/WHITE LETTERS "LSHH-5"	9001-KN799BP	
47	1		2" X 8" LEGEND PLATE, BLACK FIELD/ 3/4" WHITE LETTERS FIELD PANEL FP-1		
48	1		1" X 2-7/16" LEGEND PLATE, BLACK FIELD/ 1/4" WHITE LETTERS VACUUM PUMP VP-1		
49	1		1" X 2-7/16" LEGEND PLATE, BLACK FIELD/ 1/4" WHITE LETTERS TRANSFER PUMP P-1		
50	1		1" X 2-7/16" LEGEND PLATE, BLACK FIELD/ 1/4" WHITE LETTERS TRANSFER PUMP P-2		
51	1		1" X 2-7/16" LEGEND PLATE, BLACK FIELD/ 1/4" WHITE LETTERS MOTORIZED VALVE SV-1		
52	1		1" X 2-7/16" LEGEND PLATE, BLACK FIELD/ 1/4" WHITE LETTERS MOTORIZED VALVE SV-2		
53	1		1" X 2-7/16" LEGEND PLATE, BLACK FIELD/ 1/4" WHITE LETTERS MOTORIZED VALVE SV-3		
54	1		1" X 2-7/16" LEGEND PLATE, BLACK FIELD/ 1/4" WHITE LETTERS MOTORIZED VALVE SV-4		
55	1		1" X 2-7/16" LEGEND PLATE, BLACK FIELD/ 1/4" WHITE LETTERS MOTORIZED VALVE SV-5		
56	6'		1" X 3" WIRING DUCT, WHITE	E1X3WH6	
57	6'		1" WIRING DUCT COVER, WHITE	C1WH6	
58	12'		2" X 3" WIRING DUCT, WHITE	E2X3WH6	
59	12'		2" WIRING DUCT COVER, WHITE	C2WH6	
60	1	WB806	WARNING BEACON, 120 VAC	150-0006	
			MOTOR STARTERS/CONTACTORS		
61	1	M621	IEC CONTACTOR, 5 HP, 240 VAC, 1Ø, 120 VAC COIL	100-A30ND3	
62	1	M621	IEC BIMETALLIC THERMAL OVERLOAD RELAY, 16-24 AMP	193-BSC24	
63	1	M624	IEC CONTACTOR, 2 HP, 240 VAC, 1Ø, 120 VAC COIL	100-A12ND3	
64	1	M624	IEC BIMETALLIC THERMAL OVERLOAD RELAY, 6-10 AMP	193-BSC10	
65	1	M627	IEC CONTACTOR, 1 HP, 240 VAC, 1Ø, 120 VAC COIL	100-A09ND3	
66	1	M627	IEC BIMETALLIC THERMAL OVERLOAD RELAY, 4.0-6.0 AMP	193-BSB60	
67	1	MCR300	CONTACTOR, 20 AMP, 2 POLE, 120 VAC COIL		
			SENSORS		
68	1	LSHH-2	LIQUID LEVEL SWITCH	130-0041	
69	1	LSHH-3	TANKFULL PROBE, 40', W/ FORKS	50-0033	
70	3	LSL/H-4	CONDUCTIVITY PROBE, WARRICK SERIES 3W2 (303 S.S.)	3W2	
71	1	LSHH-6	CONDUCTIVITY PROBE, WARRICK SERIES 3W2 (303 S.S.)	3W2	
			PROBES & EXTENSIONS		
72	1	LSH/L-1,2	MULTILEVEL PROBE, CUSTOM		
73	1	LSH/L-3	MULTILEVEL PROBE, CUSTOM		
74	1	LSHH-5	DEWATERING 50', LEVEL PROBE W/ ONE FLOAT	50-0079-01	

COMPONENT LIST

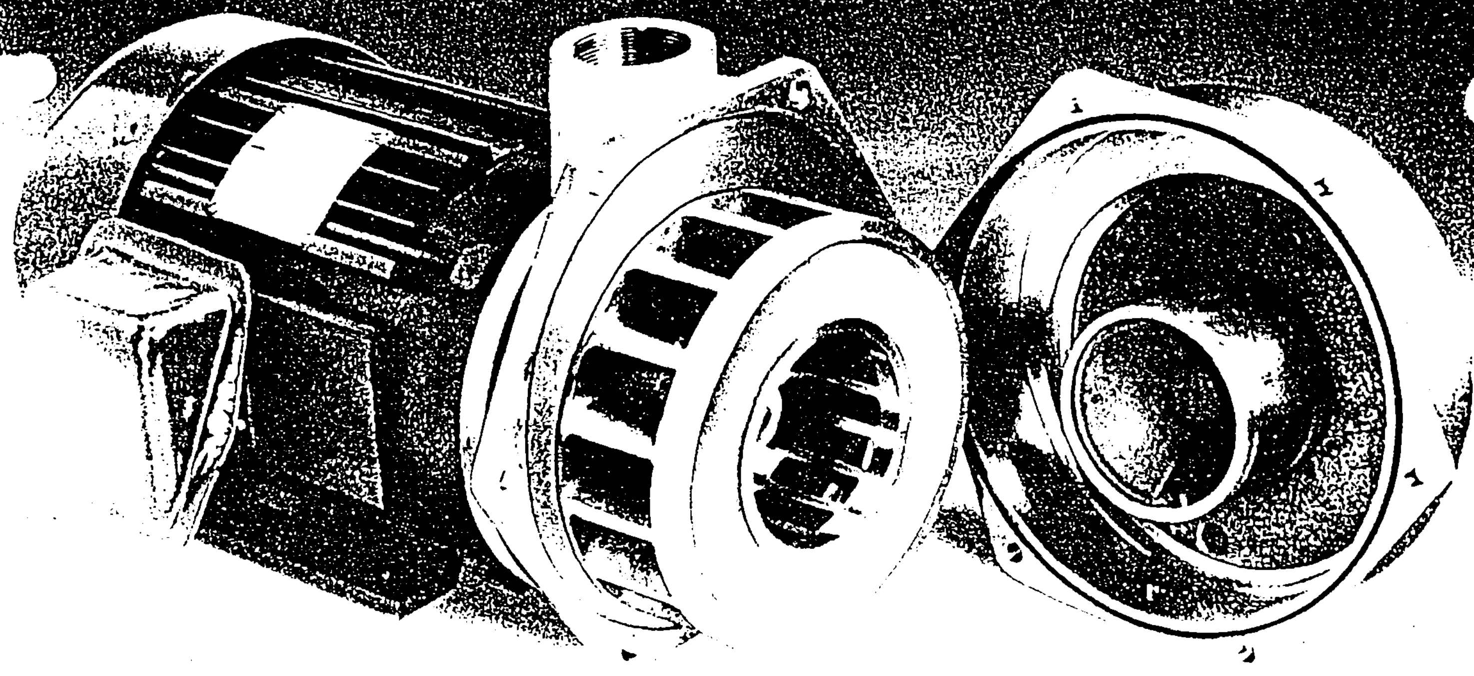
PROJECT NAME: APPLIED EARTH SCIENCE 12/2/96
PROJECT NUMBER: 1028

ITEM	NO. REQ.	P&ID LABEL	DESCRIPTION AND SPECIFICATIONS	PART NUMBER	SERIAL NUMBER
	PUMPS				
109	1	VP-1	LIQUID RING VACUUM PUMP MODEL # A-75 WITH 5 HP, 240VAC, 1 Ø, XP MOTOR		
110	1	P-1	TOTAL FLUIDS PUMP MODEL #18G1514, 10.1 TO 20 GPM W/ RYTON DIFFUSERS AND IMPELLERS		
111	1		MOTOR, 1 1/2 HP, 240V, 1 PH, 2 WIRE	100-0052	
112	1	P-2	MYERS MODEL 100M-1/2, 3 15/16" IMPELLER	100-0120	
113	1	P-2	1/2 HP, 240 VAC, 1 PH, XP, 56C, 3450 RPM, 5/8" SHAFT, W/O.L. PROT.		

VACUUM PUMP

Fluid-Vac®

Liquid Ring Vacuum Pumps



Installation and
Service Manual

Contents

1.0 General Description

1.1 LIQUID RING VACUUM PUMPS - PRINCIPLE OF OPERATION

The liquid ring pump removes gases by means of an impeller rotating freely in an eccentric casing. The pumping is done by a liquid, usually water, that is fed into the pump and thrown by centrifugal force into a moving ring along the casing or cover wall.

When gas or vapor enters the suction port, it is trapped by the whirling impeller blades and a liquid piston that expands in the eccentric lobe of the casing. As the impeller rotates, the liquid is then pushed inward by the narrowing space between rotor and casing, compressing the trapped pocket of gas. Finally the compressed gas is released through a discharge port as the impeller completes the revolution.

The direct contact between the liquid ring and the gas makes the pump ideal for wet applications and for handling condensibles that are discharged with the gas and liquid. Unlike rotary vane and piston pumps, the operation of a liquid ring vacuum pump is nearly isothermal and without vibration. There is no oil to be changed or pollutant released into the environment. Because there are no valves and no rubbing parts, a liquid ring pump is virtually maintenance-free.

With liquids other than water, vapor pressure in the pump can be reduced for high vacuum or compatibility achieved with specific process gases. In some cases, distillate or another fluid is introduced directly into the suction pump inlet and used as the liquid seal.

Liquid ring pumps are also commonly staged with positive displacement blowers, air and steam ejectors for greater capacity and higher vacuum. Atlantic Fluidics offers many such staged units—including its patented Fluid-Vac two-stage system with roots-type blower, liquid ring back up and unique fluid coupling design.

1.2 FLUID-VAC SPECIAL FEATURES

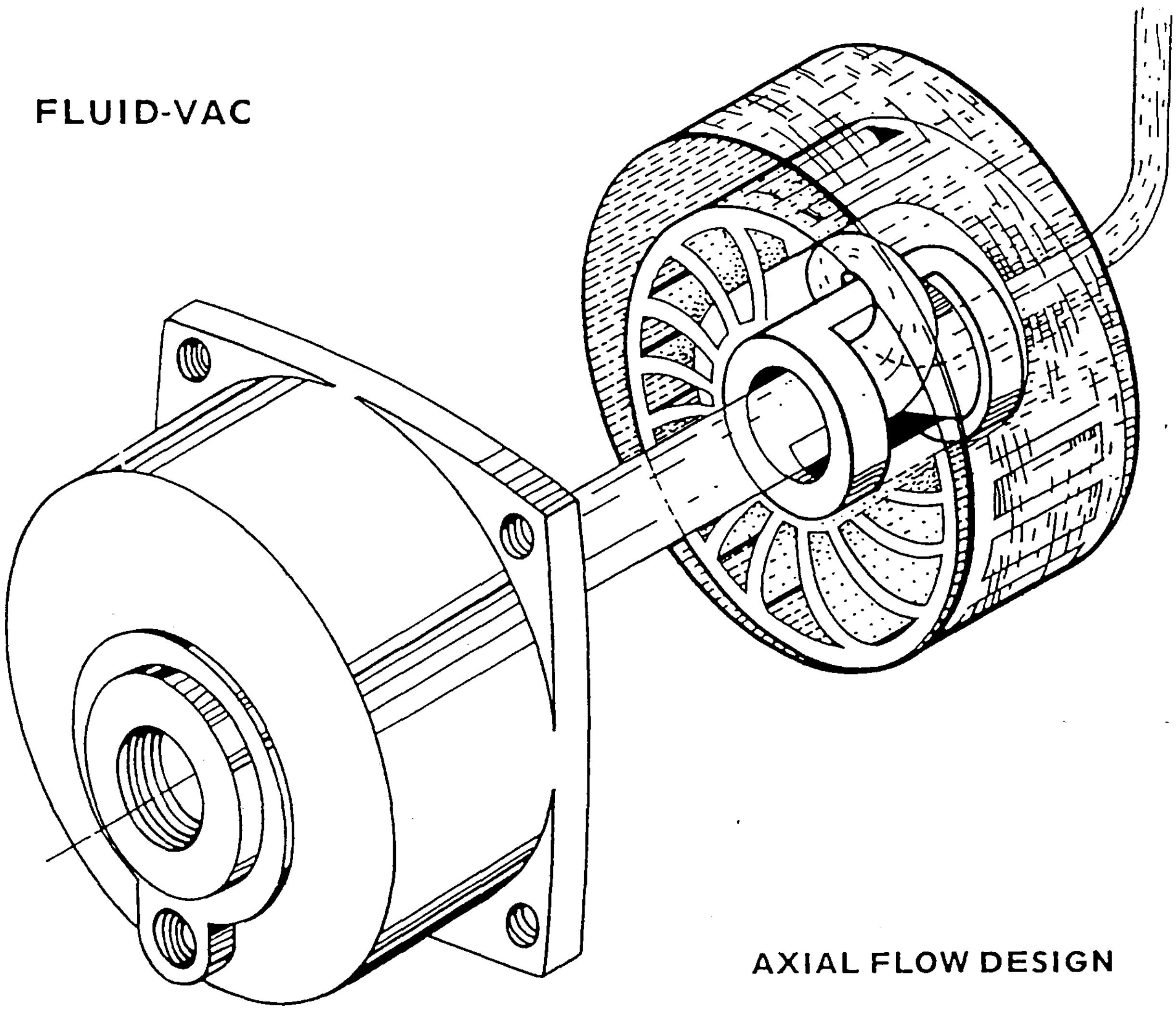
One of the distinguishing features of an Atlantic Fluidics' pump is an axial flow design that permits the widest range and highest vacuum of any single-stage liquid ring pump. A fixed port cylinder concentric with the rotor bore directs the gas along the shaft axis, into the suction ports of the rotor, and finally back through the rotor and rear of the pump for discharge.

Because the gas flow is along the motor shaft (and not at right angles), the pump can start flooded without damage and has excellent water handling capacity. The use of a shrouded rotor also increases pumping efficiency for high vacuum and lower water consumption. The pump head, close-coupled to a "C"-Face motor, is extremely compact and requires no interstage manifold as do the older style pumps and their copies.

Further advantages to Fluid-Vac pumps include the use of modern O-Rings and Mechanical Seals rather than gaskets and stuffing boxes, and a replaceable port cylinder for fast in-the-field repair. The standard material of construction is bronze with a hardened aluminum bronze rotor so that any wear or damage is relegated to the least expensive parts.

1.3 WARRANTY

The seller warrants and guarantees products of its manufacture against defective workmanship or material for a period of one year from the date of shipment from its factory. This warranty and guarantee is expressly and strictly limited to replacing without charge any part or parts which prove to its satisfaction, upon examination, to have been defective and which have not been neglected, abused or misapplied, provided the Buyer gives the Seller immediate



written notice upon discovery of any claimed defect. Material deemed defective must be returned to the factory, transportation charges to and from the factory to the place of origin pre-paid, F.O.B.

Anything herein to the contrary notwithstanding, the Seller will guarantee component parts manufactured by others, including, but not limited to, prime movers, starting equipment, electrical apparatus, and auxiliary fittings only to the same extent of the guarantee made by the manufacturer of such equipment.

1.4 SERVICE and PARTS

Fluid-Vac pumps are 100% designed and manufactured in the United States. All parts are maintained in inventory for immediate shipment from our factory in Stamford, Connecticut. At the back of this manual is a list of parts and recommendations for spares to keep on hand.

The reputation of Atlantic Fluidics is staked on fast service and practical assistance in designing vacuum systems for specific applications. Specializing in the liquid ring field, the company was created by and for ENGINEERS.

2.0 Installation

2.1 LOCATION

Because of its close-coupled design, a Fluid-Vac pump is ideal for applications where space is critical. Its vibrationless operation permits direct bolting to the floor or mounting on a baseplate anywhere that is convenient for piping. The standard motors furnished by Atlantic Fluidics are of either the Open Drip Proof (ODP) variety, for dry indoor locations, or Totally Enclosed Fan Cooled (TEFC) for areas where the motor may be exposed to water. Special motors are available for hazardous locations.

The pump needs no adjustment, alignment or coupling, guard, etc., and because the pump runs COOL, no special ventilation is necessary—or access for checking sight glasses and oil.

In choosing a location, the main consideration should be the pump's proximity to the vacuum system and convenience for draining discharge and piping the seal water.

2.2 GENERAL PIPING INSTRUCTIONS

The Inlet, Discharge and Seal Water Piping require observance of three basic rules:

A. Piping must be free of all welding shot, slag and other foreign matter that could damage pump.

B. Piping must be supported independently to avoid stress on pump casing.

C. Piping should be of the same diameter as the pipe connections on pump.

2.21 VACUUM INLET PIPING

Inlet piping is a simple matter of connecting the pump to the vacuum system. Models A10, A15 and A20 vacuum pumps have threaded one inch connections on their covers for direct piping. The larger pumps feature flange faces.

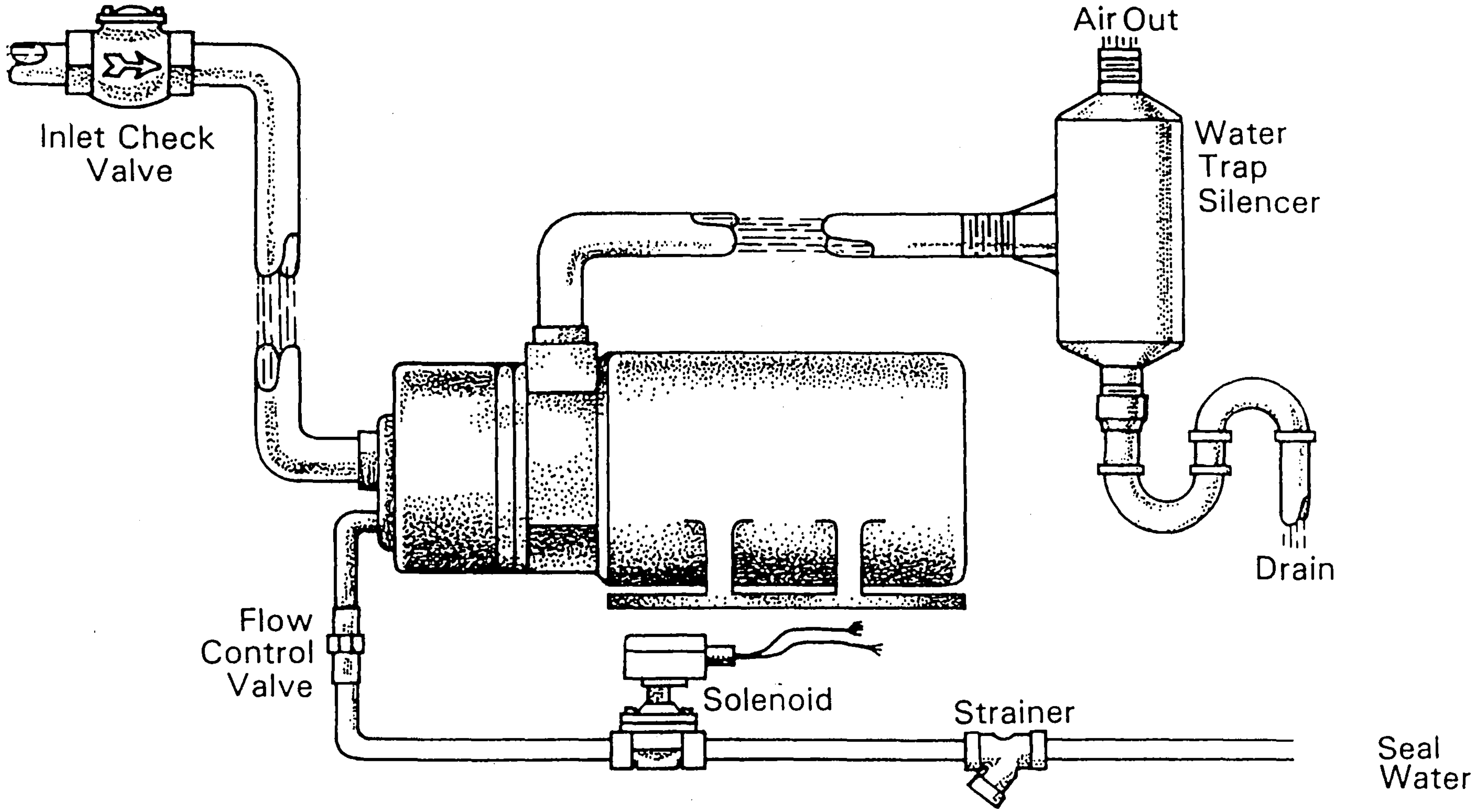
An inlet check valve is recommended to prevent vacuum loss and back streaming when the pump shuts down. Avoid using spring loaded valves not designed for vacuum service.

An optional vacuum gauge can be mounted between the pump and check valve to measure inlet vacuum.

2.22 DISCHARGE PIPING

Depending on the application, there are a number of ways to handle the discharged liquid and gas. If there are no pollutants, the simplest scheme is to discharge directly into a drain. An Atlantic Fluidics pump can carry up to a ten foot discharge head provided the piping from that height is pitched toward a drain or other receptacle. EXCESSIVE BACK PRESSURE CAN ADVERSELY AFFECT PUMP PERFORMANCE.

A second method is to run the discharge through a mechanical separator removing water from the gas. Water contaminated by sanitary waste or noxious gas may be recirculated as seal water or discharged into a sanitary sewer or tank. The nature of the contaminant will determine how often recirculated water must be changed.



PIPING SCHEMATIC

2.23 SEAL WATER PIPING

Unless liquid is pumped directly through the vacuum inlet connection, most applications require separate piping for seal water to enter the pump. The seal water inlet is located directly below the vacuum inlet on the pump's face. Water, the most widely used liquid seal, can be piped directly from a tap or recirculated from a discharge separator tank. Be sure to specify if seal liquids other than water are to be used: Atlantic Fluidics will make recommendations regarding compatibility of materials, power requirements etc.

The following accessories are recommended:

A. Flow control valve (see Seal Water Requirements)

B. Solenoid Valve (to shut off water when pumping stops)

C. Strainer (to prevent foreign matter from entering the pump)

For more information about recirculating seal water, consult Atlantic Fluidics.

2.3 ELECTRICAL CONNECTIONS

Refer to the motor label or conduit box for correct wiring. Most motors are three phase and will be damaged if single phased. Derating for 50 cycle operation at different voltages is possible if specified on motor label. Otherwise, refer questions to manufacturer or Atlantic Fluidics.

Be sure to jog motor before start-up to insure correct wiring and rotation.

3.0 Operation

3.1 SEAL WATER REQUIREMENTS

Fluid-Vac liquid ring pumps, because of their exclusive axial flow design, have the ability to handle large amounts of water and can start up flooded without damage.

Seal water flow is not critical and flow rates can be adjusted for a wide variety of applications. For most applications the optimum seal water rates are given below:

	Vacuum Range		
Pump Model	0" - 10" Hg.	10" - 25" Hg.	Over 25" Hg.
A5	1.0 GPM	1.5 GPM	2.0 - 3.0 GPM
A10	1.0 GPM	1.5 GPM	2.0 - 3.0 GPM
A15	1.5 GPM	2.0 GPM	2.0 - 3.0 GPM
A20	2.0 GPM	2.0 GPM	2.5 - 3.5 GPM
A75	2.0 GPM	2.5 GPM	3.0 - 4.0 GPM
A100	2.0 GPM	2.5 GPM	3.0 - 4.0 GPM
A130	2.0 GPM	3.0 GPM	4.0 - 5.0 GPM
A200	3.0 GPM	5.0 GPM	6.0 - 8.0 GPM

The water supply can be regulated by either a flow restrictor or manually by valve. The object is to balance performance against water consumption and power.

THE PUMP MUST NEVER RUN DRY. The solenoid valve must be in an open position for pumping.

3.2 START-UP

Once the pump is fully piped and wired for operation, be sure no foreign matter may enter and possibly damage the pump. Check for welding shot, slag or other metal bits.

Before starting the pump, turn the motor shaft by hand to be sure it is free to rotate. On TEFC motors, you may turn the rear fan. With ODP motors, the rotor can be turned via the discharge port or the front vents beneath motor.

If a hard rub is experienced, the pump should be checked internally for interference. As long as the shaft can be turned by hand, the pump is operable. A hard rub is indicative of improper alignment, and the pump should be disassembled and realigned.

A final check is to jog the motor, making sure water is introduced into the pump and that rotation is in accordance with the arrow cast on pump face. If no flow of air or vacuum reading is immediately apparent, rewire the motor accordingly. Rotation should be counter clockwise facing the pump inlet.

The pump is now ready for operation.

3.3 STOPPING PUMP

Once the power is shut off, be sure water is stopped from entering the pump. A solenoid valve in the seal water line is recommended to shut off flow simultaneously with cessation of pumping.

An inlet check valve is recommended to prevent vacuum loss or back flow to the system.

3.4 MAINTENANCE

As a general rule, maintenance is not required for Fluid-Vac pumps. Because there are no rubbing parts and with water acting as coolant and lubrication during pumping, wear is minimized. It is recommended that the motor bearings be greased every four years. For further information refer to the Trouble-Shooting Chapter of this manual.

To prevent foreign matter from entering the pump, a strainer is recommended for the seal water line and the usual precautions taken in the pump inlet piping.

4.0 Trouble shooting

4.1 PUMP WILL NOT TURN ON START-UP

(a) Check wiring and power to pump.

(b) Remove pump cover to check for anything that may be binding the rotor. Be sure that the rotor turns freely by hand. (Sec. 3.2)

(c) On cast iron pumps, check for internal rust if pump has been left idle for a long period. Rust can build up to the point where internal clearances are closed. Remove rust and reassemble.

(d) In areas where there is hard water being fed into the pump, check for scale deposits that may hinder rotation. Scale should be removed by acidizing, but refer to the factory for recommended procedures.

(e) If the motor fails to turn, be sure it isn't a motor problem. Burn-out may occur if a three-phase motor is single phased.

4.2 NO PUMPING ON START-UP

(a) Check pump rotations. It may be rotating in reverse. Rewire motor to correct.

(b) Check seal water. Water must be fed continuously into the pump.

4.3 POOR PUMP PERFORMANCE, LOW VACUUM

(a) Check vacuum pump while running by sealing off inlet piping and reading vacuum at the pump suction. If high vacuum is achieved, look for leaks in the vacuum system. The pump capacity is a function of high vacuum performance and will conform to the published performance curve at standard conditions. High seal water temperatures will lower the vacuum because of the increase in vapor pressure. Altitude, barometric pressure, and gas temperature can also affect high vacuum performance.

(b) If high vacuum is not achieved on blank-off, the problem lies in the vacuum pump. Poor pump performance can be caused by the following:

- Pump may not be getting enough water. Adjust water supply and observe change in the performance.

- Internal parts may be worn or badly scarred. Remove cover/port cylinder assembly and check for wear on the port cylinder, rotor and cover lands. Most wear will be limited to the softer bronze port cylinder which should slide easily into the rotor bore. Replace port cylinder if necessary. You may also polish the port cylinder and rotor bore with a fine emery cloth for smooth fit.

4.4 PUMP UNUSUALLY NOISY

(a) Unusual continuing noise from the motor end is probably an indication that the motor bearings are bad. Remove cover and spin rotor by hand. You should be able to detect bearing noise. If indicated, replace motor bearings.

(b) Cavitation. The vacuum pump should not be operated on blank suction for any length of time. When liquid ring vacuum pumps are starved for air, cavitation will result in a rattling noise and vibration in the pump. Cavitation can be eliminated by providing a slight air bleed into the vacuum system.

4.5 HIGH AMPS

(a) Flooding the pump with too much water, particularly at low vacuum, can overload the motor. Adjust seal water supply.

(b) Internal rubbing of rotor with stationary parts can cause excessive loading. Shut off pump and rotate by hand (see 3.2) to see if rotor turns freely. Internal rubbing may be due to scale build-up, a galling foreign material or by misalignment of parts. (see 4.1 & 4.3b)

5.0 Service and Repair

5.0 SERVICE and REPAIR

Fluid-Vac liquid ring vacuum pumps have been designed to minimize down time by allowing for fast in-the-field repair. Time and money-saving features include:

- Modern O-Rings and mechanical seals for zero leakage and easy replacement.

- Front end disassembly for fast access to major internal parts.

- Shaft mounted assembly for easy alignment and indicating.

- Replaceable port cylinder that unscrews from cover and requires no special shimming or adjustment.

- Standard rotor made of G-metal and Aluminum bronze to relegate wear and damage to the softer port cylinder.

- American-made stock parts available for immediate shipment.

5.1 DISASSEMBLY OF PUMP

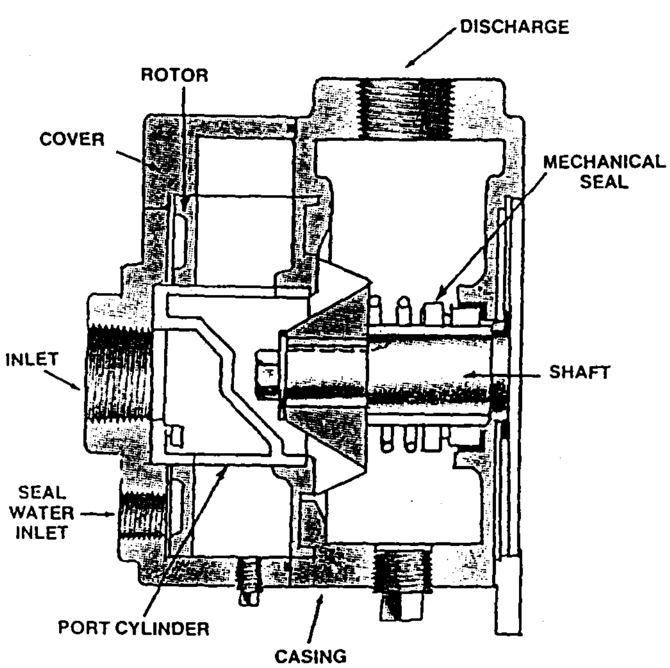
The pump may be disassembled while bolted to the baseplate by removing suction and seal water piping and working from cover to motor. Most repair work will not require full disassembly, but please refer to the exploded pump diagram in following these steps:

(a) Shut off all valves controlling flow of fluids to and from the pump casing. Disconnect external piping.

(b) Remove bolts connecting cover to casing. The cover and port cylinder assembly will slide straight outward. The port cylinder is dismounted from cover by removing three socket head cap screws.

(c) Remove hex head lock screw and washer from motor shaft. Use a bearing puller to remove rotor without damage to casing. Be sure to protect the threaded shaft bore.

(d) Slide shims, mechanical seal, sleeve bushing and O-Ring off shaft.



(e) Unbolt casing from motor face.

(f) Save any and all shims from shaft and casing assemblies for proper realignment.

5.2 ASSEMBLY OF PUMP

Before commencing assembly of the pump, carefully inspect all parts for signs of unusual wear, abrasion and corrosion. O-Rings should be checked for cracks or brittleness and the carbon face of the mechanical seal examined for scratches.

Replace all parts as needed and proceed as follows:

STEP ONE: Casing, Sleeve and Seal Assembly

The mechanical seal is composed of a seat (#8a), seal (#8b), and spring (#8c). The seat is a ceramic ring with a rubber boot that is pressed firmly into the rear of casing. Lubricant is recommended for ease in inserting rubber boot in the seal housing bore. BE VERY CAREFUL NOT TO SCRATCH THE CERAMIC FACE DURING HANDLING AND INSERTION.

Once the seal seat is in place, mount casing (#1) on the motor face using the original shims for alignment. The larger pump casings are mounted on four studs extending from motor face, while the smaller casings (Models A10, 15, 20) are secured by four hex head bolts.

Next slip the small O-Ring (#11) over shaft till it touches the shaft shoulder and place the sleeve/bushing (#9) on top so that its chamfered end presses against O-Ring.

To complete the assembly, lubricate the sleeve so that the rest of the mechanical seal (#8b) can be pressed on with the carbon face in flat sliding contact with the ceramic seat. Again, AVOID SCRATCHING OR TOUCHING THE CARBON FACE. Proper tension between the seal faces is provided by the spring – leading to Step 2.

STEP TWO: Rotor Assembly and Alignment

The rotor is secured to the shaft by means of a key (#15), a hex head lock screw (#13), and a brass washer (#14). In order for the rotor to turn freely, there must be some clearance between it and the casing. On models A10, A15, and A20, this clearance is established by adding shims (#10) until no rub is felt between the back of the rotor and the casing face. On the larger pumps, shims are used to position the rotor so that the casing face lines up with the inside wall of the rotor shroud. (See photograph below)

Be sure to use a bearing puller when removing rotor to add more shims. Avoid damage to the casing face and to the threaded shaft bore. Once secured, the rotor should spin freely without any interference or rub from the casing.

To insure proper alignment, you may indicate the run-out on the front edge of the rotor. If the rotor appears to be cocked more than 2 or 3 thousandths when tightened down, find the high spot and if it is not drastically out, a light rap with a mallet will bring the rotor into correct alignment. Tightening down the rotor is facilitated by using a long bolt and several washers before inserting the actual lock bolt.

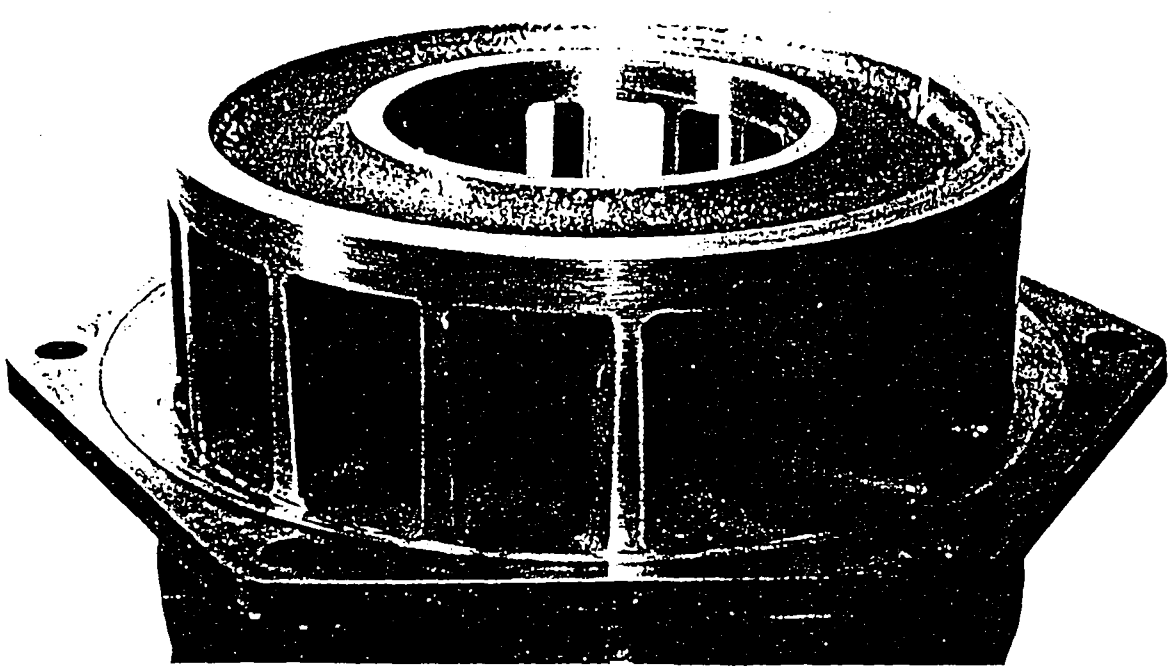
STEP THREE: Port Cylinder Assembly and Cover

The port cylinder (#3) is readily mounted on the cover (#4) by three socket head cap screws with nylon plugs (#6). A fiber gasket (#5) is used to seal the surface between cover and port cylinder while the alignment of tapped holes insures correct placement.

The final assembly is to insert O-Ring (#12) into the cover groove and then to slide the port cylinder/cover assembly into the rotor bore. The surface where cover and casing meet will be sealed by the O-Ring.

In securing the cover to the casing, the cover bolts (#19) must be drawn up uniformly. During tightening, the rotor should be turned by hand to insure easy rotation when the pump is fully assembled. Loosen the bolts and then tighten again if a hard rub is experienced. (Note that Models A75 and A100 have two socket head bolts which should be used in the bottom cover holes.)

After the drain plugs (#17, #18) have been installed with teflon tape on the threading, the vacuum pump is ready for service.



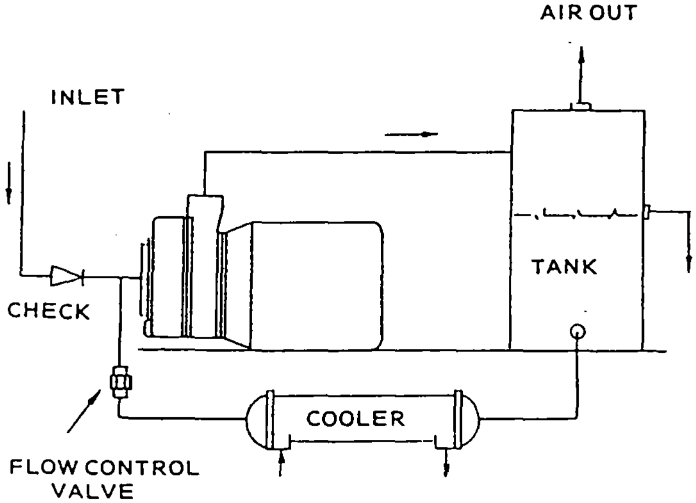
Save Water, Time and Money with FLUID-VAC Sealant Recovery Systems

In applications where water is costly, scarce or unavailable, Fluid-Vac Sealant Recovery Systems provide simple, compact and environmentally safe options for recirculating seal water and storing waste.

THE BASIC SYSTEM

The standard configuration for recirculating seal water is to pipe the pump discharge into a small separator tank where non-condensed gas is vented into the atmosphere and the water returned to the pump inlet. By having a tee connection in the inlet piping for the return (rather than through the separate seal water inlet), the pump will draw its own water requirement controlled by a flow restrictor in the return line.

The basic system offered by Atlantic Fluidics is a completely self-contained pumping system that fits almost anywhere for intermittent or low vacuum use. The package includes a close-coupled pump, baseplate, stainless steel separator tank with complete seal water and discharge piping.



HEAT EXCHANGERS

For continuous high vacuum use, a heat exchanger is recommended to counter the temperature rise from the heat of compression. Higher seal water temperatures will increase the partial gas pressure inside the pump and limit high vacuum performance. Used in conjunction with water chillers, refrigeration units, fan coils or cooling towers, a properly sized heat exchanger will maintain seal water temperatures for maximum performance.

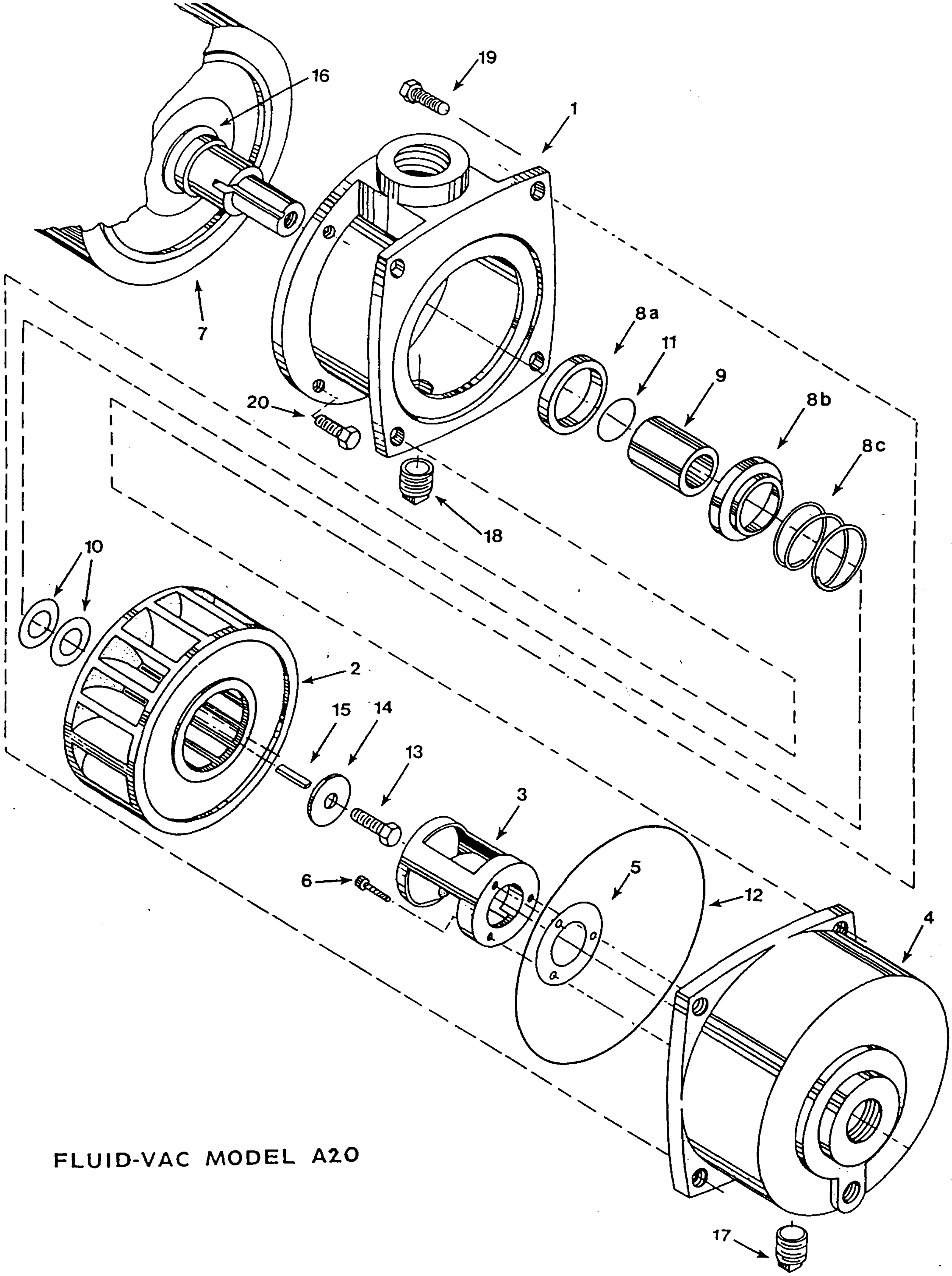
Depending on the heat to be removed and cooling system available on location, Atlantic Fluidics will specify or furnish a heat exchanger to best suit your application. For space-saving and cleaning convenience, Fluid Vac Recirculation packages can be designed with a stainless steel heat exchanger built into the separator tank. In situations where sea water is available for cooling, a separate copper/nickel heat exchanger would be recommended for handling the corrosive salt water.

OTHER ALTERNATIVES

Among the other options for reusing liquid sealant are partial recirculation systems and specially packaged units using sealants other than water (i.e. oil, perchlorethylene, etc.). In a partial recirculation loop, a certain amount of make-up water is fed into the pump to minimize temperature rise yet allow for substantial water savings.

For sealants other than water, be sure to consult Atlantic Fluidics for assistance with both the pump and recirculation sizing.

As one of two American companies specializing in liquid ring pump applications, Atlantic Fluidics invites you to inquire about specific, practical and inexpensive methods for cutting operating costs and for saving that precious natural resource - water.



FLUID-VAC MODEL A20

Parts List for Models A5 through A200

Ref.No.	Part		
1	Casing	12	O-Ring, Cover
2	Rotor	13	Lock Bolt
3	Port Cylinder	14	Washer
4	Cover	15	Key
5	Gasket (Port Cylinder)	16	Slinger
6	Cap Screws (Port Cylinder)(3)	17	Drain Plug, Cover
7	Motor	18	Drain Plug, Casing
8	Mechanical Seal Assembly a) Seat b) Seal c) Spring	19	Cover Bolts (4) A10-20 (6) A75-200
9	Shaft Sleeve	20	Casing Bolts (4)
10	Shims (Set)	20a	Casing Nuts (4) A75-A200 only
11	O-Ring, Shaft		

Parts Recommended to Keep on Hand

#3	Port Cylinder
#5	Gasket (Port Cylinder)
#8	Mechanical Seal Assembly
#10	Shims (Set)
#11	O-Ring, Shaft
#12	O-Ring, Cover
#13	Lock Bolt

Parts can be ordered directly from our Norwalk factory for immediate shipment. All parts are MADE IN AMERICA.

Contact:
PARTS DEPARTMENT
Atlantic Fluidics, Inc.
21 South Street
South Norwalk, CT 06854
(203) 853-7315
Fax (203) 866-8218

We will be happy to assist you with any questions which might arise and for advice on your application.

CONTROL PANEL

ALLEN-BRADLEY

SLC 500™ Fixed Hardware Style

Installation and Operation Manual

Summary of Changes

The information below summarizes the changes to this manual since the last printing as 1747–800 in January 1990.

New Information

The table below lists sections that document new features and additional information about existing features, and shows where to find this new information.

For This New Information	See Chapter/Appendix
Selecting Operator Interfaces	1 – Selecting Your Hardware Components
Selecting Surge Suppressors	
Transistor Output Transient Pulses	
High–Speed Counter Input Compatibility	4 – Installing Your Hardware Components
Troubleshooting I/O Modules	8 – Troubleshooting
Devices that Use the DH–485 Network	A – Setting Up the DH–485 Network
Powering the Link Coupler	
The 1771–Remote I/O Network	B – The 1771–Remote I/O Network
RS–232 Communication Interface	C – RS–232 Communication Interface
Calculating Heat Dissipation for the SLC 500 Control System	D – Calculating Heat Dissipation for the SLC 500 Control System
Wiring and Circuit Diagrams and Voltage Ranges for Your Fixed Controller	E – Wiring and Circuit Diagrams and Voltage Ranges for Your Fixed Controller

System Installation Recommendations

Chapter 2

Mounting Your SLC 500 Control System

Chapter 3

Installing Your Hardware Components

Chapter 4

Preface

Chapter 1

Selecting Your Hardware Components

Wiring Your Control System

Chapter 5

Starting Up Your Control System

Chapter 6

Maintaining Your Control System

Chapter 7

Troubleshooting

Chapter 8

Replacement Parts

Chapter 9

Setting Up the DH–485 Network

Appendix A

The 1771–Remote I/O Network

Appendix B

RS–232 Communication Interface

Appendix C

Calculating Heat Dissipation for the SLC 500 Control System

Appendix D

Wiring and Circuit Diagrams and Voltage Ranges for Your Fixed Controller

Appendix E

Preface

Read this preface first. It provides an overview of the entire manual and will acquaint you with the information that is provided throughout these pages. In this preface, you will learn about:

- who should use this manual
- how to use this manual
- related publications
- conventions used in this manual
- Allen–Bradley support

Who Should Use this Manual

The tasks and procedures in this manual require you to have some knowledge of programmable controller installation and electrical wiring. We also assume that you have a "working" knowledge of SLC™ products. If you do not have this knowledge base, obtain the proper training before attempting any of the tasks and/or procedures detailed in this manual.

How to Use this Manual

As much as possible, we organized this manual to explain, in a task–by–task manner, how to install and operate (preliminary start–up operations) the SLC 500 fixed programmable controller. This manual also provides some system design information.

Before using this manual, read over the table below and familiarize yourself with the general content of the chapters and appendixes. If you already have a topic in mind that you want to find specific information about, turn to the index at the back of the manual.

If You Want	See
An overview of the manual	The Preface
Information on how to select certain components for your SLC 500 control system	Chapter 1 — Selecting Your Hardware Components
A guide on how to prepare for the installation of your control system	Chapter 2 — System Installation Recommendations
Mounting dimensions of your fixed controller, DTAM ™, and/or 1747–AIC	Chapter 3 — Mounting Your SLC 500 Control System
Procedures on how to install your hardware components	Chapter 4 — Installing Your Hardware Components
Information on how to wire the components of your SLC 500 control system	Chapter 5 — Wiring Your Control System
A guide on how to start up your control system	Chapter 6 — Starting Up Your Control System
Information on how to maintain your control system	Chapter 7 — Maintaining Your Control System
To identify error messages generated by your control system	Chapter 8 — Troubleshooting
To replace parts of your SLC 500 control system or purchase other SLC components	Chapter 9 — Replacement Parts
Information on setting up the DH–485 network	Appendix A — Setting Up the DH–485 Network
Information on the 1771–Remote I/O network	Appendix B — The 1771–Remote I/O Network
Information on configuring the RS–232 network	Appendix C — RS–232 Communication Interface
Information on how to calculate the heat dissipation of your controller	Appendix D — Calculating Heat Dissipation for the SLC 500 Control System
Wiring and circuit diagrams and voltage ranges	Appendix E — Wiring and Circuit Diagrams and Voltage Ranges for Your Fixed Controller
Definitions of terms used in this manual	The Glossary

Related Publications

The table below provides a listing of publications that contain important information about Allen–Bradley Small Logic Controllers and their installation and application. You may want to reference them while you are installing the SLC 500 controller. (To obtain a copy of one of these publications, contact your local Allen–Bradley office or distributor.)

For	Read this Document	Document Number
An overview of the SLC 500 family of products	SLC 500 System Overview	1747–2.30
A description on how to install and use your *Modular* SLC 500 programmable controller	Installation & Operation Manual for Modular Hardware Style Programmable Controllers	1747–NI002
A procedural manual for technical personnel who use APS to develop control applications	Allen–Bradley Advanced Programming Software (APS) User Manual	1747–NM002
A reference manual that contains status file data, instruction set, and troubleshooting information about APS	Allen–Bradley Advanced Programming Software (APS) Reference Manual	1747–NR001
An introduction to APS for first–time users, containing basic concepts but focusing on simple tasks and exercises, and allowing the reader to begin programming in the shortest time possible	Getting Started Guide for APS	1747–NM001
A procedural and reference manual for technical personnel who use the APS import/export utility to convert APS files to ASCII and conversely ASCII to APS files	APS Import/Export User Manual	1747–NM006
A procedural and reference manual for technical personnel who use an HHT to develop control applications	Allen–Bradley Hand–Held Terminal User Manual	1747–NP002
An introduction to HHT for first–time users, containing basic concepts but focusing on simple tasks and exercises, and allowing the reader to begin programming in the shortest time possible	Getting Started Guide for HHT	1747–NM009
In–depth information on grounding and wiring Allen–Bradley programmable controllers	Allen–Bradley Programmable Controller Grounding and Wiring Guidelines	1770–4.1
A description on how to install a PLC–5® system	PLC–5 Family Programmable Controllers Hardware Installation Manual	1785–6.6.1
A description of important differences between solid–state programmable controller products and hard–wired electromechanical devices	Application Considerations for Solid–State Controls	SGI–1.1
An article on wire sizes and types for grounding electrical equipment	National Electrical Code	Published by the National Fire Protection Association of Boston, MA.
A complete listing of current Automation Group documentation, including ordering instructions. Also indicates whether the documents are available on CD–ROM or in multi–languages.	Allen–Bradley Publication Index	SD499
A glossary of industrial automation terms and abbreviations	Allen–Bradley Industrial Automation Glossary	AG–7.1

Conventions Used in this Manual

The following conventions are used throughout this manual:

- Bulleted lists such as this one provide information, not procedural steps.
- Numbered lists provide sequential steps or hierarchical information.
- *Italic* type is used for emphasis.
- Dimensions are in millimeters. (Dimensions in parentheses are in inches.)
- Text in `this font` indicates words or phrases you should type.

Allen–Bradley Support

Allen–Bradley offers support services worldwide, with over 75 Sales/Support offices, 512 authorized Distributors and 260 authorized Systems Integrators located throughout the United States alone, plus Allen–Bradley representatives in every major country in the world.

Local Product Support

Contact your local Allen–Bradley representative for:

- sales and order support
- product technical training
- warranty support
- support service agreements

Technical Product Assistance

If you need to contact Allen–Bradley for technical assistance, please review the information in the Troubleshooting chapter first. Then call your local Allen–Bradley representative.

Your Questions or Comments on this Manual

If you have any suggestions for how this manual could be made more useful to you, please send us your ideas on the enclosed reply card.

If you find a problem with this manual, please notify us of it on the enclosed Publication Problem Report.

Chapter 1

Selecting Your Hardware Components

This chapter provides general information on what your SLC 500 controller can do for you and an overview of the fixed control system. It also explains how to select:

- 2–slot chassis
- discrete I/O modules
- specialty I/O modules
- enclosures
- operator interfaces
- memory modules
- isolation transformers
- suppressors
- output contact protection

There is also a section on special considerations for controller installations.

This chapter does not provide you with all the information that you need to select a complete SLC 500 control system. To do this, we recommend that you use the latest version of the system overview, *SLC 500 Family of Smal' Programmable Controllers,* Publication Number 1747–2.30.

What Your SLC 500 Controller Can Do for You

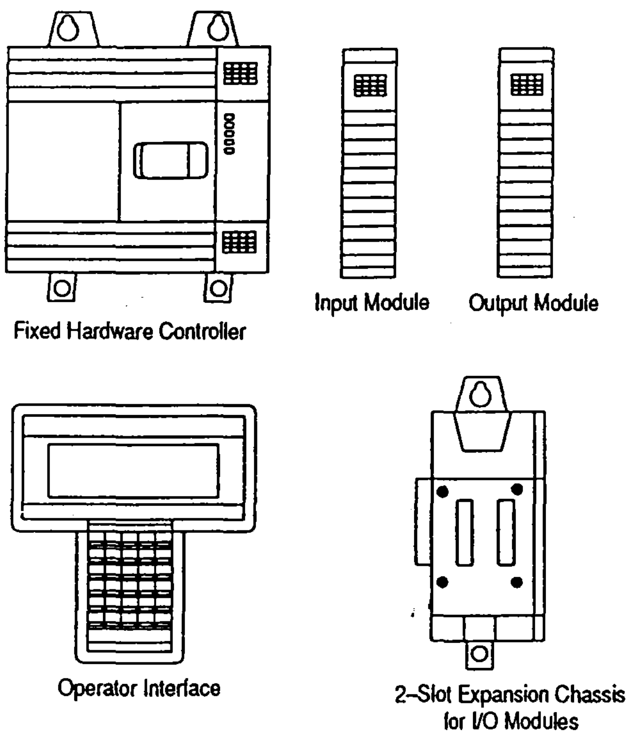
The SLC 500 programmable controller has features that previously could only be found in large programmable controllers. It has the flexibility and power of a large controller with the size and simplicity of a small controller. The SLC 500 controller offers you more control options than any other programmable controller in its class.

These programmable controllers make up a technologically advanced control system having inherent flexibility and advantages characteristic of other programmable controllers, but with one important difference — simplicity!

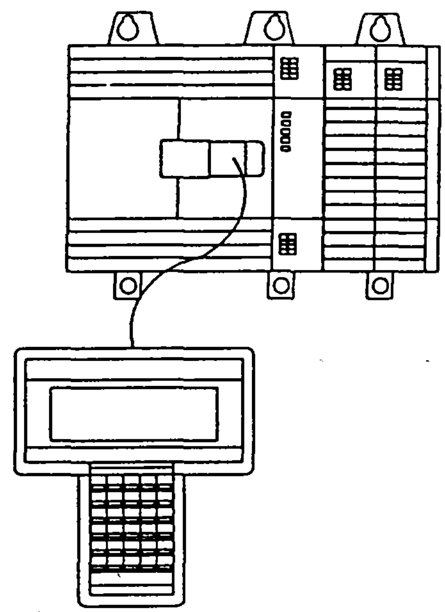
Overview of Your Fixed Control System

The basic fixed controller consists of a processor with 1,024 (1K) instruction capacity, a power supply, and a fixed number of I/O contained in a single package. The figure below shows typical hardware components for a fixed controller.

Fixed Hardware Components



Fixed Controller with 2–slot Expansion Chassis



Fixed Controller Specifications

This section provides the specifications for the SLC 500 Fixed Controller.

Description	Specification
Memory Type	Capacitor–backed RAM memory. Battery back–up optional.
Memory Backup Options	EEPROM or UVPROM
Program Memory	1K Instruction Capacity
Capacitor Memory Back–up Time	Refer to curve on page 1–4.
Battery Life	5 years
Typical Scan Time[1]	8 milliseconds/1K
Bit Execution (XIC)	4 microseconds
Program Scan Hold–up Time after Loss of Power	20 milliseconds to 700 milliseconds (dependent on loading)
Power Supply Operating Voltage	AC units: 85–265 VAC 47–63 Hz DC units: 21.6–26.4 VDC (24 VDC ± 10%)
Power Supply Fuse Protection	AC units: 120/240 VAC 1.25A DC units: 24 VDC 1.6A
Power Supply Inrush Rating	30 Amperes maximum
Maximum Power Requirement	50 VA[2]
24 VDC User Power Output Current[3]	200mA
24 VDC User Power Output Voltage[3]	20.4 – 27.6 VDC (24 VDC ± 15 %)
Wire Size	#14 AWG Max.
I/O Electrical–Optical Isolation	1500 VAC at 1 minute
1747–AIC Link Coupler Electrical–Optical Isolation	1500 VDC
LED Indicators	POWER, PC RUN, CPU FAULT, FORCED I/O, and BATTERY LOW
Noise Immunity	NEMA Standard ICS 2–230
Ambient Temperature Rating	Operating: 0°C to +60°C (+32°F to +140°F) Storage: –40°C to +85°C (–40°F to +185°F)
Humidity	5 to 95% without condensation
Vibration	Displacement: .015 inch, peak–to–peak @ 5–57 Hz
	Acceleration: 2.5 Gs @ 57–2000 Hz
	Duration: 1 hr per axis (x, y, z)
Certification	UL listed/ CSA approved

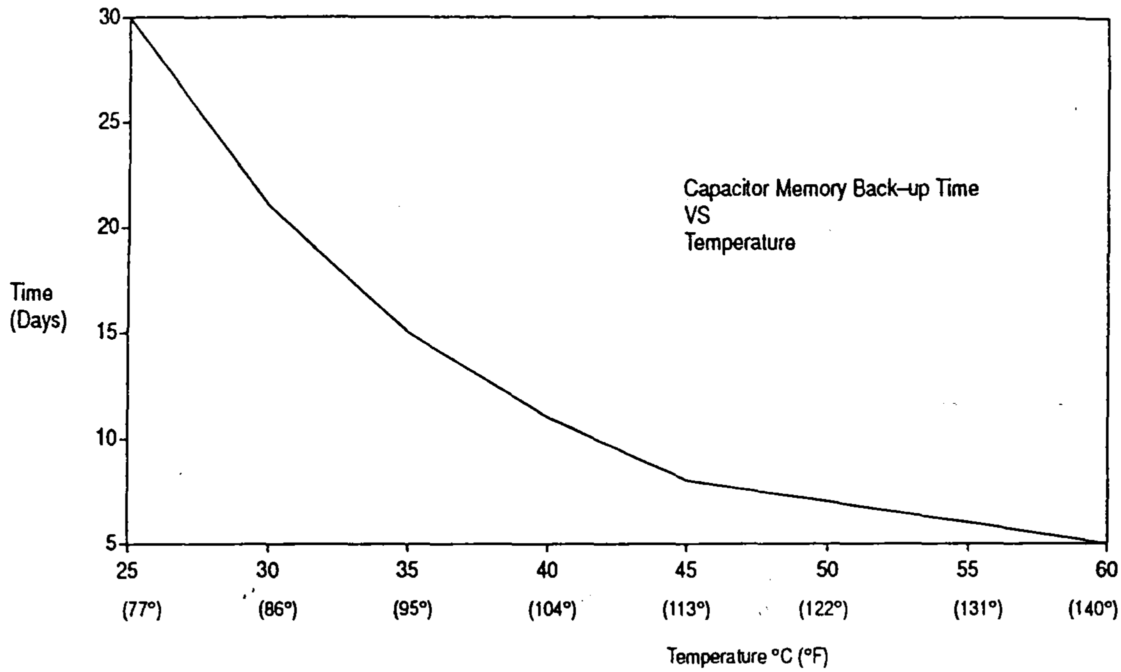
[1] *The scan times are typical for a 1K ladder logic program consisting of simple ladder logic and communication servicing. Actual scan times depend on your program size, instructions used, and the DH–485 communication.*

[2] *This specification does not include input and output values. (See page 1–6.)*

[3] *This applies only to fixed controllers that have AC line power and DC input circuits.*

Memory Backup for the SLC 500 Fixed Controller

The curve below illustrates the ability of the memory back–up capacitor to maintain the contents of the RAM in a fixed controller. To back up the memory for a longer period of time, a lithium battery, Catalog Number 1747–BA, is required.



Configuration Options

The following table provides configuration options for 20, 30, or 40 I/O points.

Catalog Number	Line Power	I/O Configuration		High–Speed Counter	User Power
		Input	Output		
1747–L20A	120/240 VAC	(12) 120 Volts AC	(8) AC/DC Relay	No	NA
1747–L30A		(18) 120 Volts AC	(12) AC/DC Relay	No	NA
1747–L40A		(24) 120 Volts AC	(16) AC/DC Relay	No	NA
1747–L20B		(12) 120 Volts AC	(8) AC Triac	No	NA
1747–L30B		(18) 120 Volts AC	(12) AC Triac	No	NA
1747–L40B		(24) 120 Volts AC	(16) AC Triac	No	NA
1747–L20C		(12) 24 Volts DC Sink	(8) AC/DC Relay	Yes	24V–200mA
1747–L30C		(18) 24 Volts DC Sink	(12) AC/DC Relay	Yes	24V–200mA
1747–L40C		(24) 24 Volts DC Sink	(16) AC/DC Relay	Yes	24V–200mA
1747–L20D		(12) 24 Volts DC Sink	(8) AC Triac	Yes	24V–200mA
1747–L30D		(18) 24 Volts DC Sink	(12) AC Triac	Yes	24V–200mA
1747–L20E		(12) 24 Volts DC Sink	(8) DC Transistor Source	Yes	24V–200mA
1747–L40E		(24) 24 Volts DC Sink	(16) DC Transistor Source	Yes	24V–200mA
1747–L20L		(12) 24 Volts DC Source	(8) DC Transistor Sink	Yes	24V–200mA
1747–L30L		(18) 24 Volts DC Source	(12) DC Transistor Sink	Yes	24V–200mA
1747–L40L		(24) 24 Volts DC Source	(16) DC Transistor Sink	Yes	24V–200mA
1747–L20R		(12) 240 Volts AC	(8) AC/DC Relay	No	NA
1747–L20P		(12) 240 Volts AC	(8) AC Triac	No	NA
1747–L30P		(18) 240 Volts AC	(12) AC Triac	No	NA
1747–L40P		(24) 240 Volts AC	(16) AC Triac	No	NA
1747–L20F	24 VDC± 10%	(12) 24 Volts DC Sink	(8) AC/DC Relay	Yes	NA
1747–L40F		(24) 24 Volts DC Sink	(16) AC/DC Relay	Yes	NA
1747–L20G		(12) 24 Volts DC Sink	(8) DC Transistor Source	Yes	NA
1747–L20N		(12) 24 Volts DC Source	(8) DC Transistor Sink	Yes	NA

Input Specifications

The following table details the input specifications for SLC 500 Fixed I/O units. See the glossary for a definition of specifications.

Inputs	Specifications	
120 VAC	On–State Voltage	85–132 VAC
	Frequency	47–63 Hz
	Off–State Voltage	30 VAC (maximum)
	Inrush Current	0.8A peak
	Nominal Input Current	12mA at 120 VAC
	Turn–On Time	35 milliseconds (maximum)
	Turn–Off Time	45 milliseconds (maximum)
	Maximum Off–State Current	2mA
240 VAC	On–State Voltage	170–265 VAC
	Frequency	47–63 Hz
	Off–State Voltage	50 VAC (maximum)
	Inrush Current	1.6A peak
	Nominal Input Current	12mA at 240 VAC
	Turn–On Time	35 milliseconds (maximum)
	Turn–Off Time	45 milliseconds (maximum)
	Maximum Off–State Current	2mA
DC Sink & Source	On–State Voltage	10–30 VDC
	Off–State Voltage	4 VDC maximum for input 0 (HSC) 5 VDC for all others
	Nominal Input Current	20mA at 24 VDC (for input 0 only) 8mA at 24 VDC (all others inputs)
	Turn–On Time	8 milliseconds (maximum)
	Turn–Off Time	8 milliseconds (maximum)
	Maximum Off–State Current	1mA

Output Specifications

The following table details the output specifications for SLC 500 Fixed I/O Units.

Outputs	Specifications	
Triac	Output Voltage	85–265 VAC
	Continuous Current (per output)	0.5 Amp at +30°C 0.25 Amp at +60°C (maximum)
	Minimum Load Current	10mA
	Turn–On Time	0.1 milliseconds (maximum)
	Turn–Off Time	10 milliseconds (maximum)
	Maximum Off–State Leakage Current	2mA
	Maximum On–State Voltage Drop	1.5V @ 0.5 Amps
	Maximum Surge Current	10 Amps for 25 milliseconds①
Transistor Sink & Source	Output Voltage	10–50 VDC
	Continuous Current (per output)	0.5 Amp at +30°C 0.25 Amp at +60°C (maximum)
	Minimum Load Current	1mA
	Turn–On Time	0.1 millisecond (maximum)
	Turn–Off Time	1 millisecond (maximum)
	Maximum Off–State Leakage Current	1mA
	Maximum On–State Voltage Drop	1.5V @ 0.5 Amps
	Maximum Surge Current	3.0 Amps for 25 milliseconds①
Relay③	Output Voltage Range	5–265 VAC, 5–125 VDC
	Continuous Current (per output)	2.5 Amps (maximum)
	Continuous Current (per group)②	8 Amps (maximum)
	Maximum Load (per chassis)	1440 VA
	Turn–On Time	10 milliseconds (maximum)
	Turn–Off Time	10 milliseconds (maximum)
	Maximum Off–State Leakage Current	0mA
	Minimum Load Current at 5 VDC	10mA

① *Repeatability is once every 1 second at +30°C. Repeatability is once every 2 seconds at +60°C.*

② *Refer to the wiring diagrams for output groupings on the fixed I/O chassis.*

③ *Surge suppression across the output device is recommended to protect relay contacts.*

Relay Contact Ratings

Maximum Volts	Amperes Make	Amperes Break	Amperes Continuous	Voltamperes Make	Voltamperes Break
240 VAC 120 VAC	7.5A 15A	0.75A 1.5A	2.5A	1800 VA	180 VA
125 VDC	0.22A		1.0A	28 VA	
24 VDC	1.2A		2.0A	28 VA	

To calculate make and break ratings for other load voltages, divide the voltampere rating by the load voltage; for example:

28 VA/48 VDC = 0.583 A

Selecting the 2–Slot Chassis

For the 20, 30, and 40 I/O fixed controllers, an optional 2–slot expansion chassis lets you add two additional I/O modules providing even more versatility. The power supply provides backplane power for the modules in the optional expansion chassis.

Refer to chapter 3 for chassis dimensions and chapter 4 for mounting directions.

Selecting Discrete I/O Modules

There are three types of I/O modules: input, output, and combination I/O. They are available in a wide variety of densities including 4, 8, 16, and 32 point and can interface to AC, DC, and TTL voltage levels. Output modules are available with solid–state AC, solid–state DC, and relay contact type outputs.

For a complete, up–to–date listing of discrete I/O modules and their specifications, contact your Allen–Bradley sales office for the latest product data entitled *Discrete Input and Output Modules,* Publication Number 1746–2.35.

Refer to chapter 4 for installation directions.

Selecting Speciality I/O Modules

The SLC 500 family offers specialty I/O modules that enhance your control system. These modules range in function from analog interface to motion control, from communication to high–speed counting.

For a complete, up–to–date listing of specialty I/O modules and their specifications, contact your Allen–Bradley sales office for the latest System Overview entitled *SLC 500 Family of Small Programmable Controllers,* Publication Number 1747–2.30, or for a related product data.

Refer to chapter 4 for installation directions.

Selecting Enclosures

The enclosure protects the equipment from atmospheric contamination. Standards established by the National Electrical Manufacturer's Association (NEMA) define enclosure types, based on the degree of protection an enclosure will provide. Use a fan to circulate the air of sealed enclosures that use convection cooling to dissipate heat. Select a NEMA–rated enclosure that suits your application and environment. The enclosure should be equipped with a disconnect device. To calculate the heat dissipation of your controller, see appendix D.

Selecting Operator Interfaces

Use an operatoı interface to program and/or monitor your SLC 500 controller. You can choose from several Allen–Bradley operator interface devices.

Programming with a Hand–Held Terminal (1747–PT1)

Use the Hand–Held Terminal (HHT) to configure the SLC 500 controller, enter/modify a user program, download/upload programs, monitor control operation, and test/troubleshoot. When equipped with a battery (1747–BA), the HHT retains a user program in memory for storage and later use.

The display area accommodates 8 lines x 40 characters. You can display fi rungs of a user program. The top row of keys are the menu function keys.

Important: Using the HHT, you can program the SLC 5/01™ and 5/02™ processors and the SLC 500 fixed controllers. You cannot, however, program the SLC 5/03 processor.

Refer to the *Hand–Held Terminal User Manual*, Catalog Number 1747–NP002, for information on programming your fixed controller with the HHT.

Programming with Advanced Programming Software (APS) on an IBM Compatible Computer

The Advanced Programming Software (APS) can be used with an Allen-Bradley T45, T47, or T50 terminal, an IBM®-AT or XT, a Compaq® Portable, Portable II, Deskpro™ 286, 386/SX, 386, a Tandy™ 3000HL, Toshiba™ 3100E, or GATEWAY 2000™ models 386DX/25, 386DX/33, 486DX/33, and 486DX2/50 personal computer. Your computer must have:

- 640 Kbytes of RAM (extended or expanded memory is recommended, but not required)
- 10 Mbyte fixed-disk drive (APS requires a minimum or 2.5 MBytes of free disk space.)
- DOS version 3.1 or higher

Advanced Programming Software, 1747–PA2E

APS, Catalog Number 1747–PA2E, comes on 5–1/4 and 3–1/2 inch disks. You must have DOS installed in your computer. You also must have at least 550 Kbytes of free memory to execute the APS software. Like the Hand–Held Terminal, APS lets you configure the SLC 500 controller, enter/modify a user program, restore/save programs to the SLC 500, monitor controller operation, and test/troubleshoot. You can also:

- create and print ladder diagrams, data tables, instruction cross references, and configurations
- use cut/copy/paste editor
- store multiple programs in the memory of the computer (on the hard disk)

Refer to the *Advanced Programming Software User Manual*, Catalog Number 1747–NM002, and the *Advanced Programming Software Reference Manual*, Catalog Number 1747–NR001, for information on programming your fixed controller with APS.

DH–485 Interface Converter (1747–PIC)

For communication, use an RS–232/DH–485 Interface Converter between the computer and SLC controller. The converter includes a 279.4 mm (11.0 in.) ribbon cable, already attached to the converter, for connection to the computer serial port and a Catalog Number 1746–C10 cable for connection to the controller.

Monitoring with a Data Table Access Module (1747–DTAM–E)

The Data Table Access Module (DTAM) is a plant floor device that lets you access data file information, change operating modes, monitor and clear processor faults, and transfer the user program between RAM and an EEPROM memory module with any SLC 500 family processor. *You cannot use it to create new programs.*

Important features of DTAM include:

- shorthand addressing, which provides easier access to data files
- display prompts in six, user–selectable languages: English, French, German, Italian, Spanish, and Japanese
- UL listed, CSA Certified
- NEMA type 12 and 13 enclosures
- point–to–point interface to an SLC family processor, or as a network device on a DH–485 network

Refer to the *Data Table Access Module (DTAM) User Manual*, Catalog Number 1747–ND013, for information on monitoring your fixed controller with the DTAM.

EEPROM and UVPROM Memory Modules

These optional memory modules provide a non–volatile memory back–up in a convenient modular form. The modules plug into a socket on the controller.

You can store (save) your program in the EEPROM by inserting it into the processor and using either the Hand–Held Terminal or Advanced Programming Software.

Use of the UVPROM provides you with an extra degree of program security because the user program cannot be altered while it is installed in the controller. You can program the UVPROM with commercially available UVPROM programming and erasing equipment. You can use an EEPROM module as a master, or you can use an archived processor file as the source by using the APS PROM translator utility.

Adapter sockets are required when inserting memory modules into commercially available PROM programmer. The memory module fits into the adapter socket and then into a PROM programmer.

ATTENTION: Make sure the adapter is inserted properly or damage could result.

The following table lists the types of memory modules that are available fo. the fixed controller. Also listed are the manufacturer part number for determining compatibility with an external PROM burner.

Description	Catalog Number	Manufacturer	Manufacturer's Part Number
1K User Words EEPROM	1747–M1	NEC	uPD28C64 – 250
		OKI	MSM28C64ARS – 20
		XICOR	X28C64BP – 25
		SEEQ	PE28C64 – 250
4K User Words EEPROM	1747–M2	XICOR	X28C256DI – 25
			X28256DI – 25
		SEEQ	DE28C256 – 25
1K User Words UVPROM	1747–M3	Fujitsu	MBM27C64 – 25
4K User Words UVPROM	1747–M4	Not compatible with the fixed controller.	
Adaptor Socket	1747–M5	NA	NA

Selecting Isolation Transformers

If there is high frequency conducted noise in or around your distribution equipment, we recommend that you use an isolation transformer in the AC line to the power supply. This type of transformer provides isolation from your power distribution system and is often used as a "step down" transformer to reduce line voltage. Any transformer used with the controller must have a sufficient power rating for its load. This power rating is generally expressed in voltamperes (VA).

To select an appropriate isolation transformer, you must calculate the power required by the fixed I//O chassis and any input circuits and output loads that are connected through this transformer. The power requirement of any fixed I/O unit is 50 VA.

The power requirement for the input circuits is determined by the number of inputs, the operating voltage, and the nominal input current. The power requirement for output loads is determined by the number of outputs, the load voltage, and load current.

For example, if you have a 1747–L30B fixed unit with 18 AC inputs (12mA at 120 VAC) and 12 triac outputs (0.5A at 120 VAC), the power consumed would be:

$$50 + (18)(120)(0.012) + (12)(120)(0.5) = 796 \text{ VA}$$

Important: In this case, 0.5 Amp is the maximum rating of the triac output (at +30° C). If your load draws less than 0.5 Amp, this figure may be reduced accordingly. The output portion of the VA calculation should reflect the current requirements of your loads.

In general, we recommend that the transformer is oversized to provide some margin for line voltage variations and other factors. Typically a transformer that is 25% larger than the calculated VA is sufficient.

Special Considerations

The recommendations given previously provide favorable operating conditions for most controller installations. Your application may involve one or more of the following adverse conditions. Additional measures can be taken to minimize the effect of these conditions.

Excessive Line Voltage Variations

The best solution for excessive line voltage variation is to correct any feeder problems in your distribution system. Where this does not solve the line variation problem, or in certain critical applications, use a constant voltage transformer. If you require a constant voltage transformer, connect it to the power supply *and* all input devices connected to the SLC 500 controller.

Connect output devices on the same power line, but their connection along the power line is normally made before the constant voltage transformer. A constant voltage transformer must have a sufficient power rating for its load.

Excessive Noise

When you operate the SLC 500 controller in a "noise polluted" industrial environment, special consideration should be given to possible electrical interference.

The following reduces the effect of electrical interference:

- SLC 500 controller design features
- proper mounting of controller within an enclosure
- proper equipment grounding
- proper routing of wiring
- proper suppression added to noise generating devices

Potential noise generators include inductive loads, such as relays, solenoids, and motor starters when operated by "hard contacts" like push buttons or selector switches. Suppression may be necessary when such loads are connected as output devices or when connected to the same supply line that powers the controller.

Lack of surge suppression on inductive loads may attribute to processor faults and sporadic operation, RAM memory can be corrupted (lost) and I/O modules may appear to be faulty or reset themselves.

For extremely noisy environments, use a memory module and program it for auto loading on processor fault or power cycle for quick recovery.

Selecting Surge Suppressors

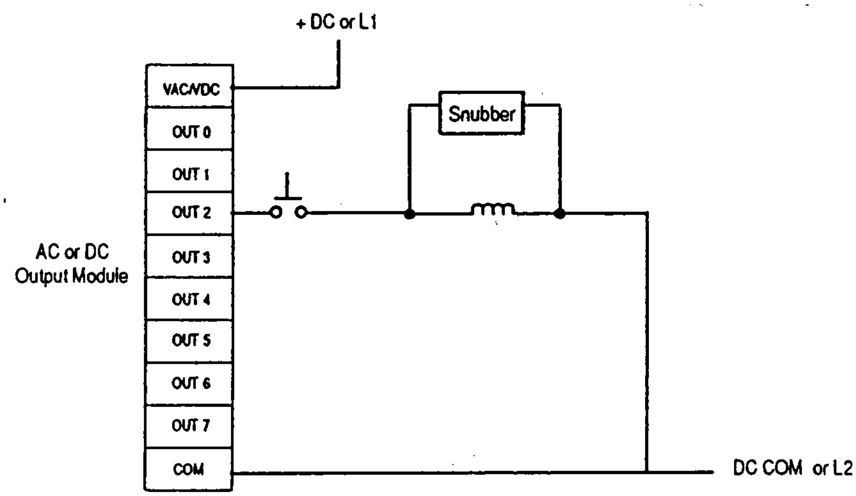
Most output modules have built–in surge suppression to reduce the effects of high voltage transients. However, we recommend that you use an additional suppression device if an output module is being used to control an inductive device such as:

- relays
- solenoids
- motor starters
- motors

Additional suppression is especially important if your inductive device is in series with or parallel to a hard contact such as:

- pushbuttons
- selector switches

By adding a suppression device directly across the coil of an inductive device, you will reduce the effects of voltage transients caused by interrupting the current to that inductive device and prolong the life of the switch contacts. The diagram below shows an output module with a suppression device.



If you connect an SLC 500 controller triac output to control an inductive load, we recommend that you use varistors to suppress noise. Choose a varistor that is appropriate for the application. The surge suppression we recommend for triac outputs when switching 120 VAC inductive loads is Harris MOV, part number V220 MA2A. For a 509 motor starter, use a 599–K04 or 599–KA04 series C or later MOV with triac outputs.

Consult the varistor manufacturer's data sheet when selecting a varistor for your application.

ATTENTION: Damage could occur to SLC 500 triac outputs if you use suppressors having RC networks. Allen–Bradley AC surge suppressors *not recommended* for use with triacs include Catalog Numbers 199–FSMA1, 199–FSMA2, 1401–N10, and 700–N24.

Allen–Bradley surge suppressors recommended for use with Allen–Bradley relays, contactors, and starters are shown in the table below.

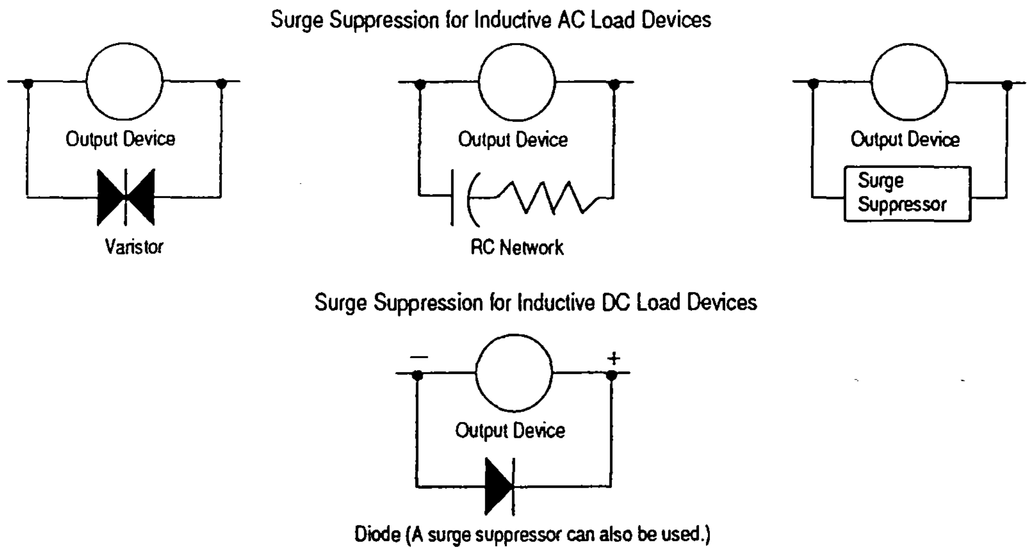
Device	Coil Voltage	Suppressor Catalog Number
Bulletin 509 Motor Starter Bulletin 509 Motor Starter	120 VAC 240 VAC	599–K04[1] 599–KA04[1]
Bulletin 100 Contactor Bulletin 100 Contactor	120 VAC 240 VAC	199–FSMA1[2] 199–F5MA2[2]
Bulletin 709 Motor Starter	120 VAC	1401–N10[2]
Bulletin 700 Type R, RM Relays	AC coil	None Required
Bulletin 700 Type R Relay Bulletin 700 Type RM Relay	12 VDC 12 VDC	700–N22 700–N28
Bulletin 700 Type R Relay Bulletin 700 Type RM Relay	24 VDC 24 VDC	700–N10 700–N13
Bulletin 700 Type R Relay Bulletin 700 Type RM Relay	48 VDC 48 VDC	700–N16 700–N17
Bulletin 700 Type R Relay Bulletin 700 Type RM Relay	115–125 VDC 115–125 VDC	700–N11 700–N14
Bulletin 700 Type R Relay Bulletin 700 Type RM Relay	230–250 VDC 230–250 VDC	700–N12 700–N15
Bulletin 700 Type N, P, or PK Relay	150V max, AC or DC	700–N24[2]
Miscellaneous electromagnetic devices limited to 35 sealed VA		

[1] *This is an MOV without a capacitor. The 599–K04 or 599–KA04 MOV must be series C or later when used with triac outputs. Do not use series A or B with triac outputs.*

[2] *Not recommended for use with triac outputs.*

Selecting Contact Protection

Inductive load devices such as motor starters and solenoids may require the use of some type of surge suppression to protect the controller output contacts. Switching inductive loads without surge suppression can *significantly* reduce lifetime of relay contacts. The figure below shows the use of surge suppression devices.



Contact Protection Methods for Inductive AC and DC Output Devices

These surge suppression circuits connect directly across the load device. This reduces arcing of the output contacts. Suitable surge suppression methods for inductive AC load devices include a varistor, an RC network, or an Allen–Bradley surge suppressor. These components must be appropriately rated to suppress the switching transient characteristic of the particular inductive device.

For inductive DC load devices, a diode is suitable. A 1N4004 diode is acceptable for most applications. A surge suppressor can also be used. See table on page 1–15.

We recommend that you locate the suppression device as close as possible to the load device.

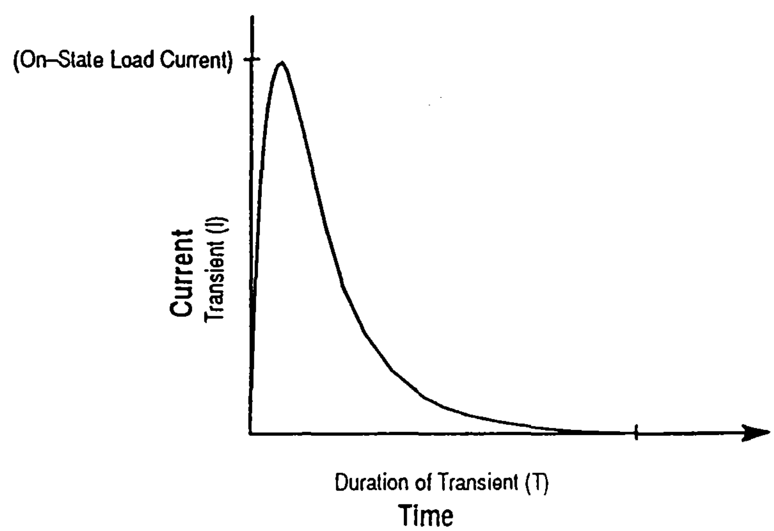
Transistor Output Transient Pulses

This section applies to the following SLC 500 Fixed I/O processors and SLC 500 I/O modules that have transistor outputs.

Fixed I/O Processors	I/O Modules
1747–L20E	1746–OB8
1747–L20G	1746–OV8
1747–L20L	1746–OB16
1747–L20N	1746–OBP16
1747–L30L	1746–OV16
1747–L40E	1746–OB32
1747–L40L	1746–OV32

For the SLC 500 products listed above, the maximum duration of the transient pulse occurs when minimum load is connected to the output. However, for most applications the energy of the transient pulse is not sufficient to energize the load.

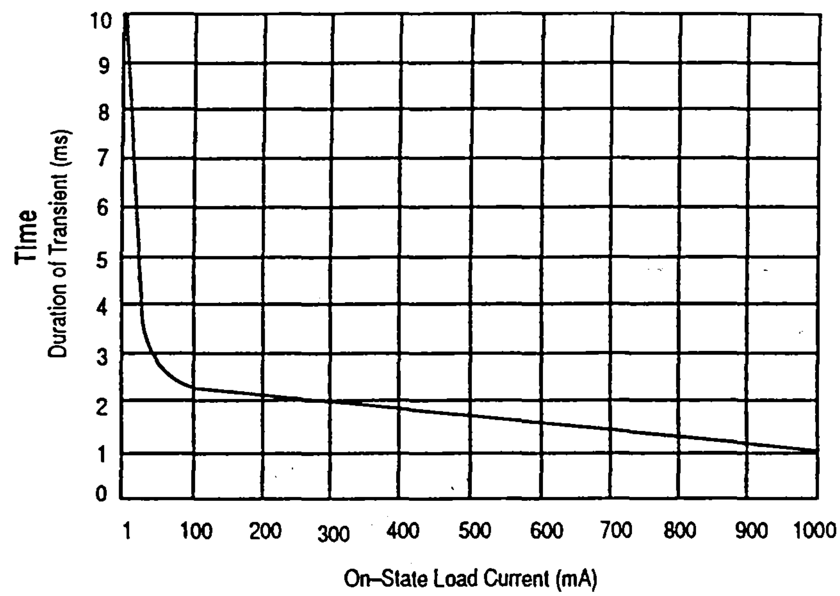
ATTENTION: A transient pulse occurs in transistor outputs when the external DC supply voltage is applied to the common output terminals (e.g., via the master control relay). The sudde application of voltage creates this transient pulse. (See the following graph.) This condition is inherent in transistor outputs and is common to solid state devices. A transient pulse can occur regardless of the processor having power or not.



To reduce the possibility of inadvertent operation of devices connected to transistor outputs, adhere to the following guidelines:

- Either ensure that any programmable device connected to the transistor output is programmed to ignore all output signals until after the transient pulse has ended,
- or add an external resistor in parallel to the load to increase the on–state load current. The duration of the transient pulse is reduced when the on–state load current is increased.

The duration of the transient pulse is proportional to the load impedance. This is illustrated in the following graph.



Example

Increasing the load current by 100mA decreases the transient time from approximately 7 ms to less than 2.5 ms. To calculate the size of the resistor added in parallel to increase the current, use the following information:

24V = your applied voltage

Need 100mA of load current to reduce the transient to < 2.5 ms. (taken from graph on previous page)

$$R\ (\text{Ohms}) = \frac{V\ (\text{Volts})}{I\ (\text{Amps})}$$

Resistor value (Ohms) = Applied voltage (Volts) / Desired current (Amps)
= 24 / 0.1
= 240 (Ohms)

P (Watts) = I^2 (Amps) x R (Ohms)

Actual Power (Watts) = $(\text{Desired Current})^2$ x Resistor Value
= $(0.1)^2$ x 240
= 2.4 (Watts)

Resistor size = 2 x Actual power (Watts)
= 2 x 2.4
= 4.8 (Watts)

Round resistor size to 5 Watts.

You need a resistor rated for 240 Ohms at 5 Watts to increase the load current by 100mA; thus decreasing the transient time from approximately 7 ms to less than 2.5 ms.

System Installation Recommendations

To help you install the SLC 500 programmable controller as safely and securely as possible, we have set up a few specific recommendations for you to follow.

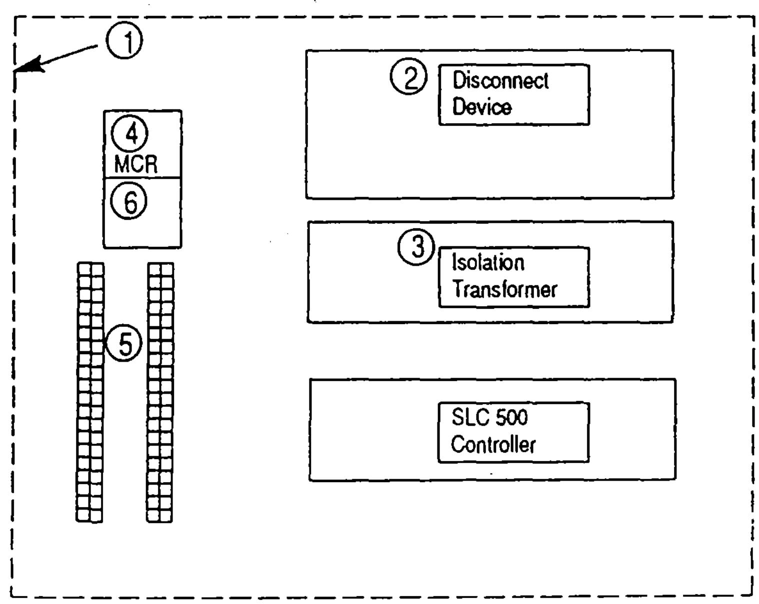
For general installation guidelines, also refer to article 70E of the National Fire Protection Association (NFPA). Article 70E describes electrical safety requirements for employee workplaces. This chapter covers the following:

- typical installation
- spacing your controllers
- preventing excessive heat
- grounding guidelines
- master control relay
- power considerations
- safety considerations
- preventative maintenance

Typical Installation

The figure below consists of some components that make up a typical installation. The following symbols are used:

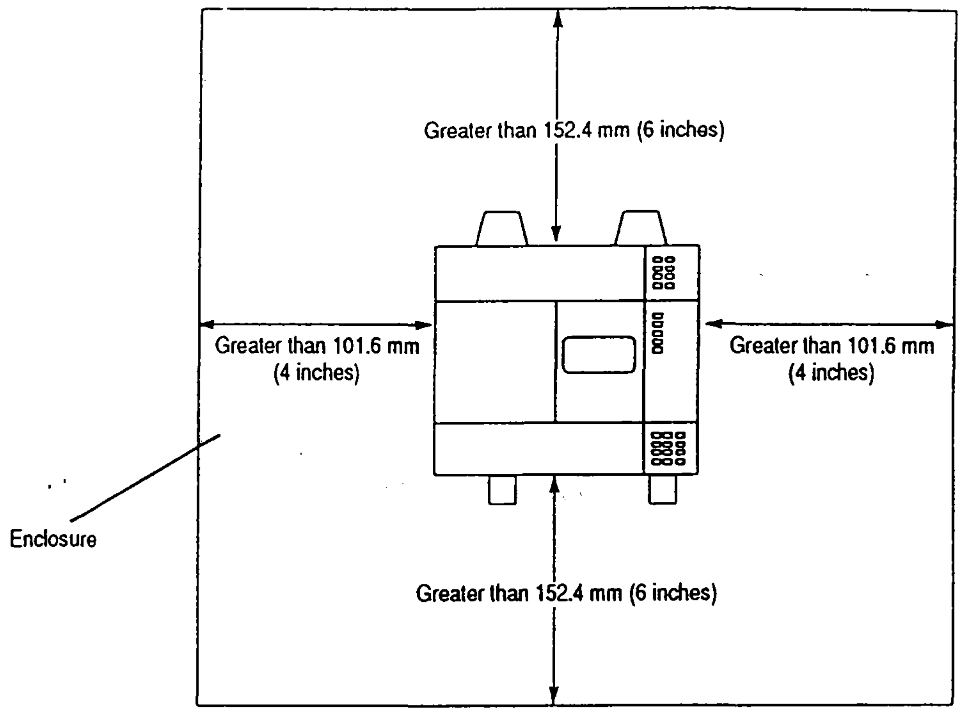
1. NEMA rated enclosure suitable for your application and environment that shields your controller from electrical noise and airborne contaminants.
2. Disconnect, to remove power from the system
3. Fused isolation transformer or a constant voltage transformer, as your application requires
4. Master control relay/emergency stop circuit
5. Terminal blocks or wiring ducts
6. Suppression devices for limiting EMI (electromagnetic interference) generation



Spacing Your Components

Follow the recommended minimum spacing shown below to allow for convection cooling within the enclosure. Air in the enclosure must be kept within a range of 0° to +60° C (+32° to +140° F).

Important: Be careful of metal chips when drilling mounting holes for the controllers. Do not drill holes above a mounted SLC 500 controller. Metal chips or clippings may short circuit electronic components of the controller and cause intermittent or permanent malfunction.



Preventing Excessive Heat

For most applications, normal convection cooling will keep the controller components within the specified operating range. Proper spacing of components within the enclosure is usually sufficient for heat dissipation.

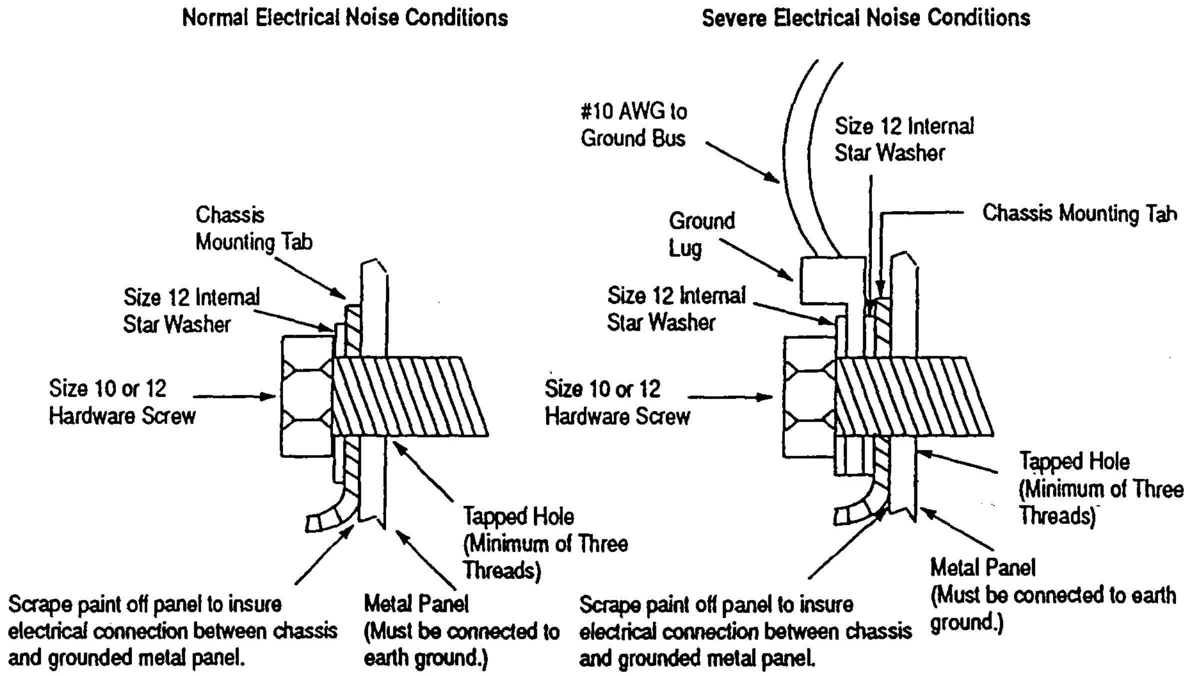
In some applications, a substantial amount of heat is produced by other equipment inside or outside the enclosure. In this case, place blower fans inside the enclosure to assist in air circulation and to reduce "hot spots" near the controller.

Additional cooling provisions might be necessary when high ambient temperatures are encountered.

Important: Do not bring in unfiltered outside air. It may introduce harmful contaminants of dirt that could cause improper operation or damage to components. In extreme cases, you may need to use air conditioning to protect against heat build-up within the enclosure.

Grounding Guidelines

In solid–state control systems, grounding helps limit the effects of noise due to electromagnetic interference (EMI). The grounding path for the controller and its enclosure is provided by the equipment grounding conductor.



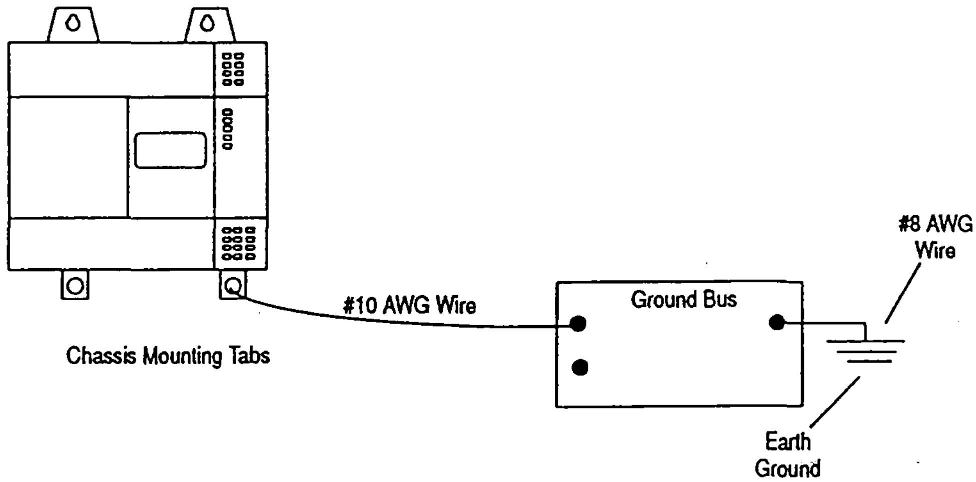
ATTENTION: The SLC 500 controller, other control devices, and the enclosure must be properly grounded. All applicable codes and ordinances must be observed when wiring the controller system.

Ground connections should run from the chassis and power supply on each controller and expansion unit to the ground bus. Exact connections will differ between applications. An authoritative source on grounding requirements for most installations is the National Electrical Code. Also, refer to *Allen–Bradley Programmable Controller Grounding and Wiring Guidelines*, Publication Number 1770–4.1.

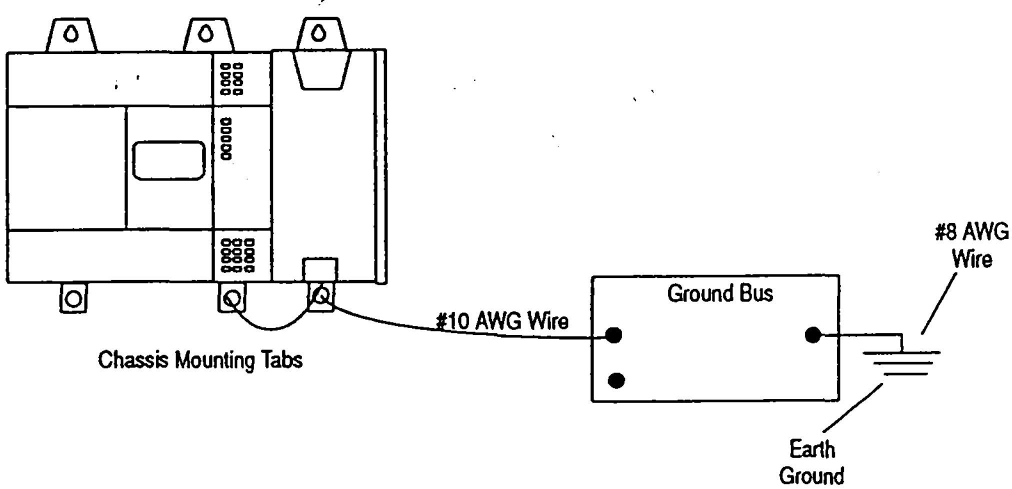
In addition to the grounding required for the controller and its enclosure, you must also provide proper grounding for all controlled devices in your application. Care must be taken to provide each device with an acceptable grounding path.

The figure below shows you how to run ground connections from the chassis to the ground bus.

SLC 500 Controller Only



SLC 500 Controller with 2–slot Expansion Chassis



Master Control Relay

A hard–wired master control relay (MCR) provides a convenient means for emergency controller shutdown. Since the master control relay allows the placement of several emergency–stop switches in different locations, its installation is important from a safety standpoint. Overtravel limit switches or mushroom head push buttons are wired in series so that when any of them opens, the master control relay is de–energized. This removes power to input and output device circuits. Refer to the figure on page 2–6.

ATTENTION: Never alter these circuits to defeat their function, since serious injury and/or machine damage could result.

Important: If you are using a DC output power supply, interrupt the output side rather than the AC line to avoid the additional delay of power supply turn–on and turn–off. The power supply should receive its power directly from the fused secondary of the transformer. Connect the power to the DC input and output circuits through a set of master control relay contacts.

Place the main power disconnect switch where operators and maintenance personnel have quick and easy access to it. If you mount a disconnect switch inside the controller enclosure, place the switch operating handle on the outside of the enclosure, so that you can disconnect power without opening the enclosure.

Whenever any of the emergency–stop switches are opened, power to input and output devices is stopped.

When you use the master control relay to remove power from the external I/O circuits, power continues to be provided to the controller's power supply so that diagnostic indicators on the processor can still be observed.

The master control relay is not a substitute for a disconnect to the controller. It is intended for any situation where the operator must quickly de–energize I/O devices only. When inspecting or installing terminal connections, replacing output fuses, or working on equipment within the enclosure, use the disconnect to shut off power to the rest of the system.

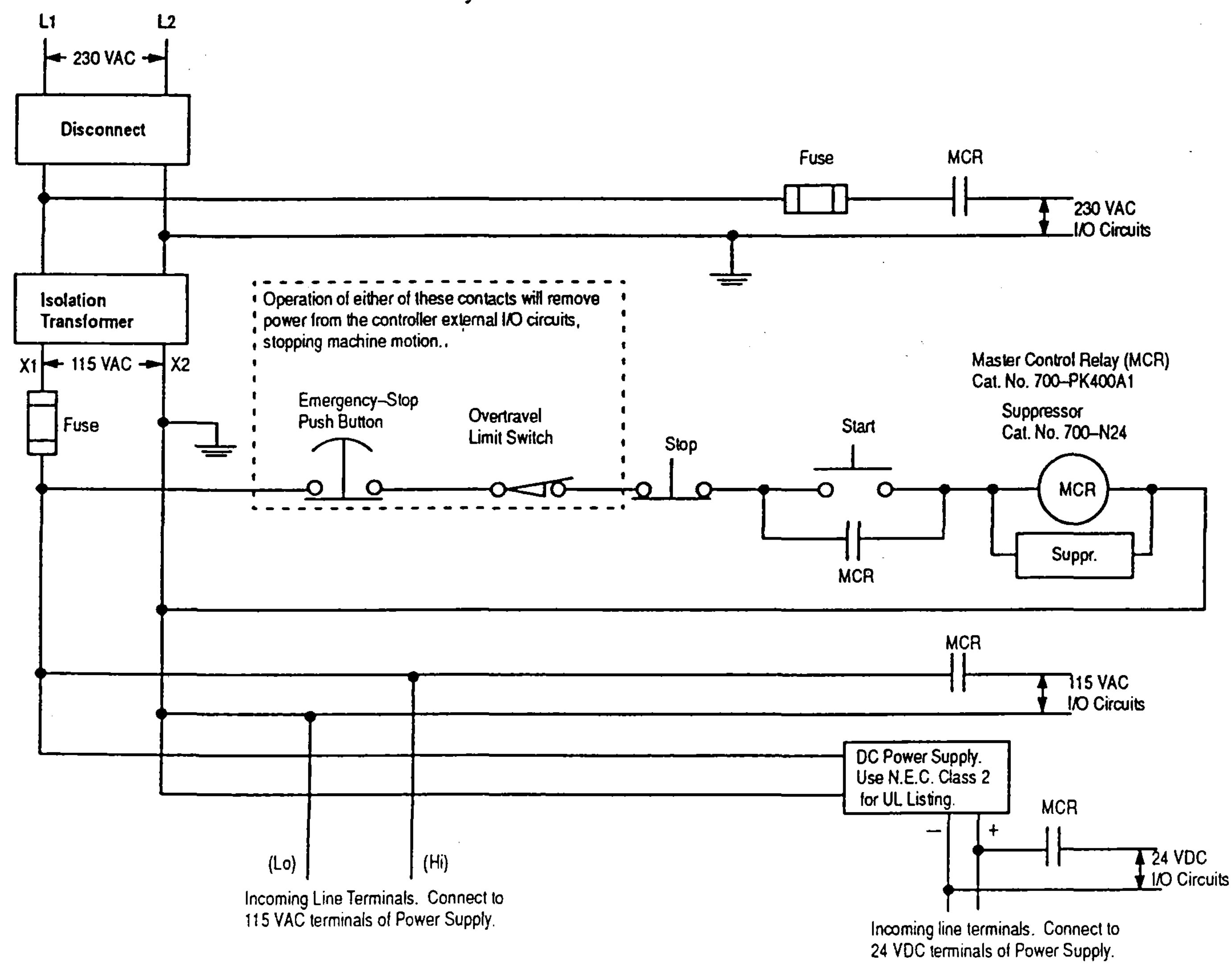
Important: The operator must not control the master control relay with the SLC 500 controller. Provide the operator with the safety of a direct connection between an emergency–stop switch and the master control relay.

Emergency–Stop Switches

Adhere to the following points concerning emergency–stop switches:

- Do not program emergency–stop switches in the controller program. Any emergency–stop switch should turn off all machine power by turning off the master control relay.
- Observe all applicable local codes concerning the placement and labeling of emergency–stop switches.
- Install emergency–stop switches and the master control relay in your system. Make certain that relay contacts have a sufficient rating for your application. Emergency–stop switches must be easy to reach.

The figure below shows the Master Control Relay Wired in Grounded System.



Power Considerations

The following explains power considerations for the SLC 500 fixed controller.

Common Power Source

We strongly recommend that the chassis power supply has the same power source as the input and output devices. This helps:

- reduce the chance of electrical interference due to multiple sources and grounds
- maintain system integrity if power is interrupted

Loss of Power Source

The chassis power supply is designed to withstand brief power losses without affecting the operation of the system. The time the system is operational during power loss is called "program scan hold–up time after loss of power." The duration of the power supply hold–up time depends on the number, type and state of the I/O, but is typically between 20 ms and 700 ms. When the duration of power loss reaches a limit, the power supply signals the processor that it can no longer provide adequate DC power to the system. This is referred to as a power supply shutdown. The POWER LED is turned off.

Input States on Power Down

The power supply hold–up time as described above is generally longer than the turn–on and turn–off times of the input circuits. Because of this, the input state change from "On" to "Off" that occurs when power is removed may be recorded by the processor before the power supply shuts down the system. Understanding this concept is important. The user program should be written to take this effect into account. For example, hard wire power to one spare input. In the user program, check to be sure that one input is on; otherwise, jump to the end of the program and avoid scanning the logic. Use of a common power source as recommended in the previous section is assumed.

Other Types of Line Conditions

Occasionally the power source to the system can be temporarily interrupted. It is also possible that the voltage level drops substantially below the normal line voltage range for a period of time. Both of these conditions are considered to be a loss of power for the system.

Safety Considerations

Safety considerations are an important element of proper system installation. Actively thinking about the safety of yourself and others, as well as the condition of your equipment, is of primary importance. Several safety areas are discussed below.

Disconnecting Main Power

The main power disconnect switch should be located where operators and maintenance personnel have quick and easy access to it. Ideally, the disconnect switch is mounted on the outside of the enclosure, so that it can be accessed without opening the enclosure. In addition to disconnecting electrical power, all other sources of power (pneumatic and hydraulic) should be de–energized before working on a machine or process controlled by an SLC controller.

Wiring Safety Circuits

Circuits installed on the machine for safety reasons, like overtravel limit switches, stop push buttons, and interlocks, should always be hard–wired directly to the master control relay. These devices must be wired in series so that when any one device opens, the master control relay is de–energized thereby removing power to the machine. Never alter these circuits to defeat their function. Serious injury or machine damage could result.

Distributing Power

There are some points about power distribution that you should be aware of. First, the master control relay must be able to inhibit all machine motion by removing power to the machine I/O devices when the relay is de–energized.

Second, if you are using a DC power supply, interrupt the load side rather than the AC line power. This avoids the additional delay of power supply turn–on and turn–off. The DC power supply should be powered directly from the fused secondary of the transformer. Power to the DC input and output circuits is connected through a set of master control relay contacts.

Testing the Master Control Relay Circuit

Any part can fail, including the switches in a master control relay circuit. The failure of one of these switches would most likely cause an open circuit, which would be a safe power–off failure. However, if one of these switches shorts out, it no longer provides any safety protection. These switches should be tested periodically to assure they will stop machine motion when needed.

Preventive Maintenance

The printed circuit boards of the controller must be protected from dirt, oil, moisture, and other airborne contaminants. To protect these boards, the controller must be installed in an enclosure suitable for the environment. The interior of the enclosure should be kept clean and the enclosure door should be kept closed whenever possible.

Regularly inspect your terminal connections for tightness. Loose connections may cause improper functioning of the controller or damage the components of the system.

ATTENTION: To ensure personal safety and to guard against damaging equipment, inspect connections with incoming power off.

The National Fire Protection Association (NFPA) provides recommendations for electrical equipment maintenance. Refer to article 70B of the NFPA for general requirements regarding safety related work practices.

Chapter 3

Mounting Your SLC 500 Control System

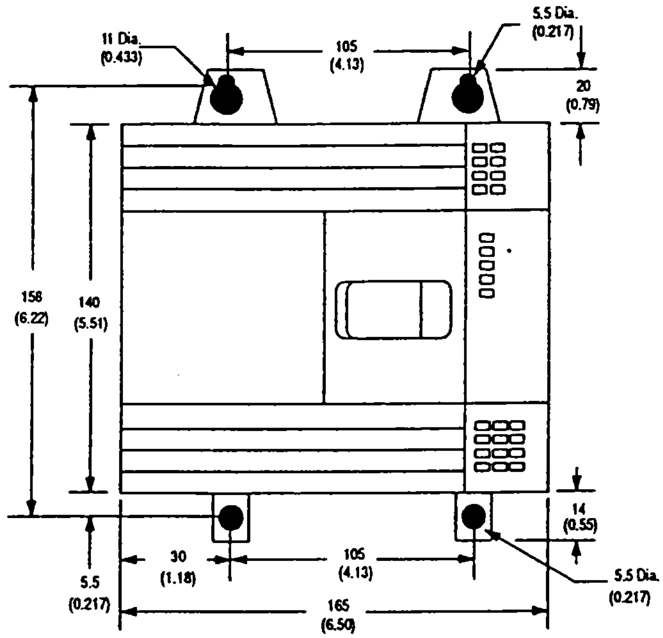
This chapter provides you with mounting dimensions for the following SLC 500 components:

- 20 I/O fixed controller
- 30 & 40 I/O fixed controller
- 2–slot expansion chassis
- link coupler (AIC)
- Data Table Access Module (DTAM)

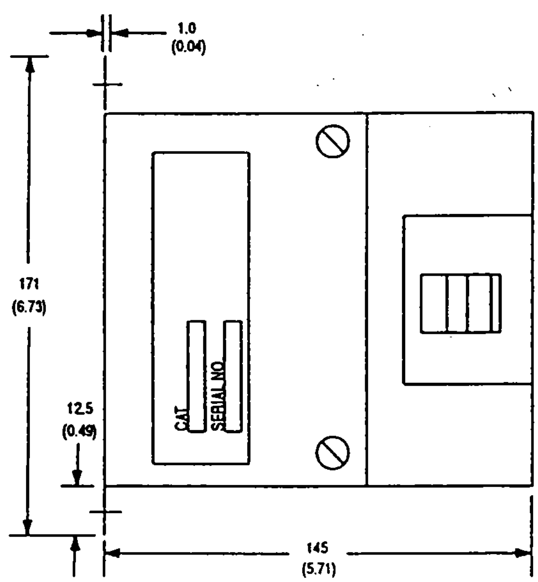
Mounting Fixed Hardware Style Units

You can mount the fixed hardware style units directly to the back panel of your enclosure using the mounting tabs and #10 and #12 screws. The torque requirement is 3.4 N–m (30 in–lbs) maximum. Dimensions are in millimeters. (Dimensions in parentheses are in inches.)

20 I/O Fixed Controller[1]



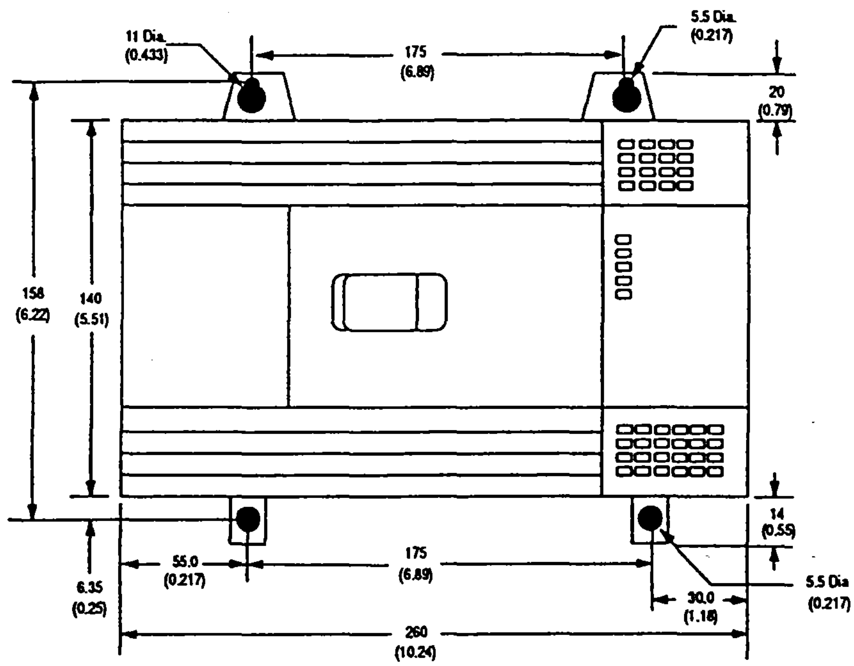
Front View



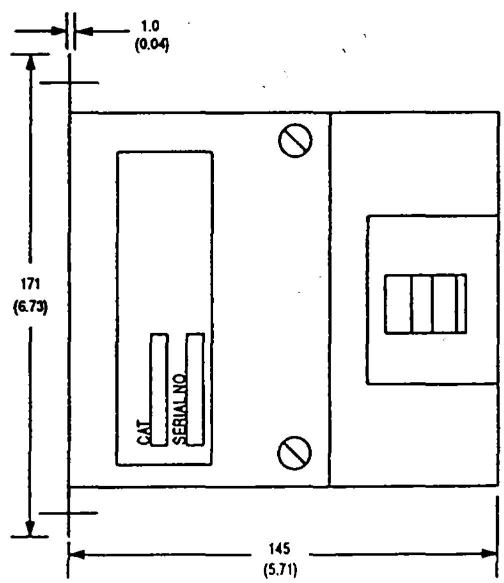
Left Side View

[1] *Dimensions are in millimeters. (Dimensions in parentheses are in inches.)*

30 and 40 I/O Fixed Controller[1]



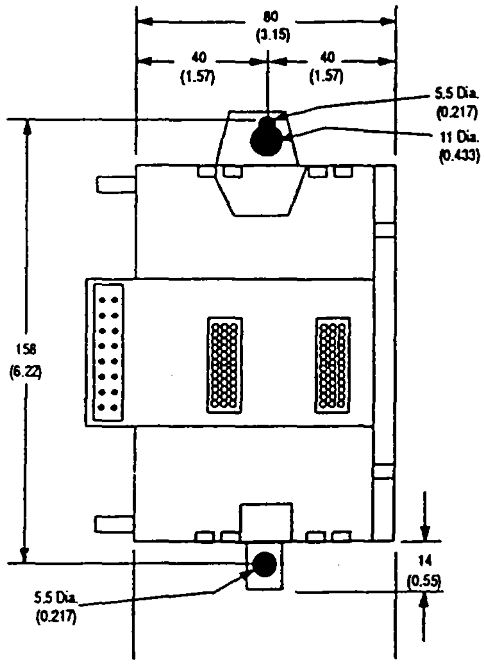
Front View



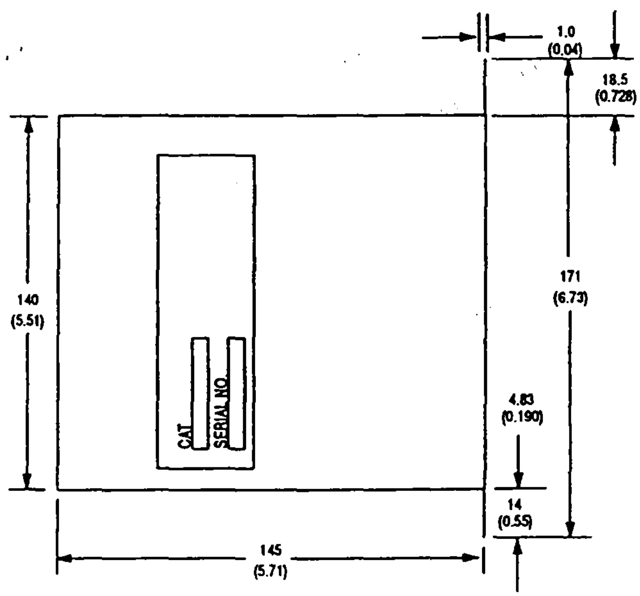
Left Side View

[1] *Dimensions are in millimeters. (Dimensions in parentheses are in inches.)*

2–Slot Expansion Chassis①



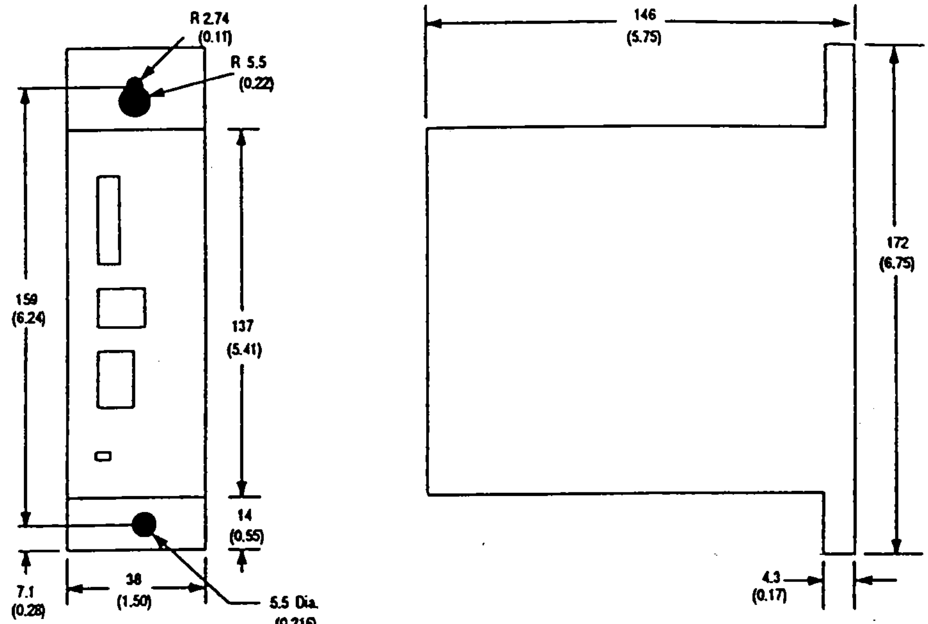
Front View



Right Side View

① *Dimensions are in millimeters. (Dimensions in parentheses are in inches.)*

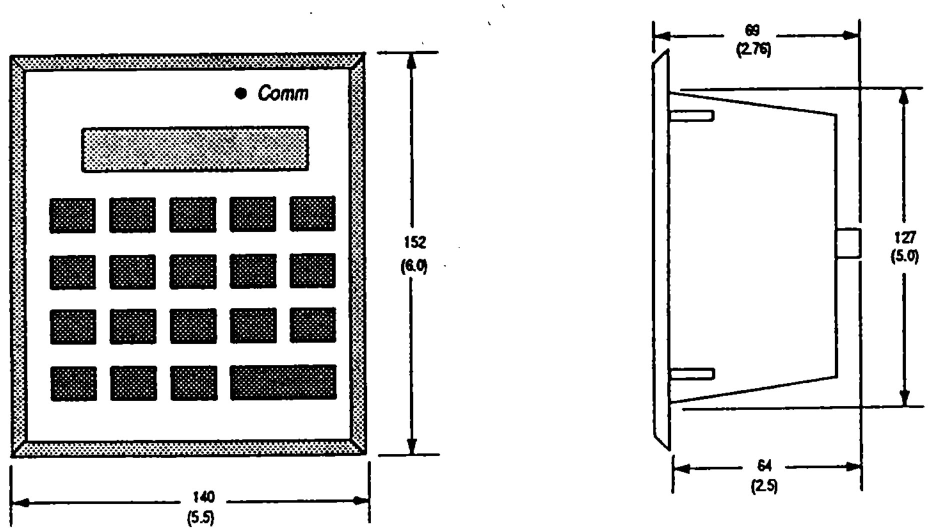
Link Coupler (AIC)①



Front View

Right Side View

Data Table Access Module (DTAM)①



Front View

Right Side View

① *Dimensions are in millimeters. (Dimensions in parentheses are in inches.)*

Chapter 4

Installing Your Hardware Components

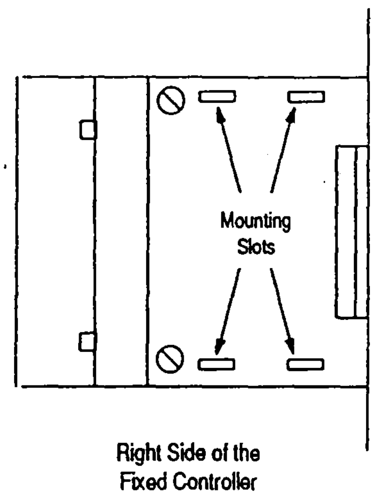
This chapter shows you how to install and remove the following hardware components:

- 2–slot expansion chassis
- I/O and speciality modules
- memory module
- high–speed counter

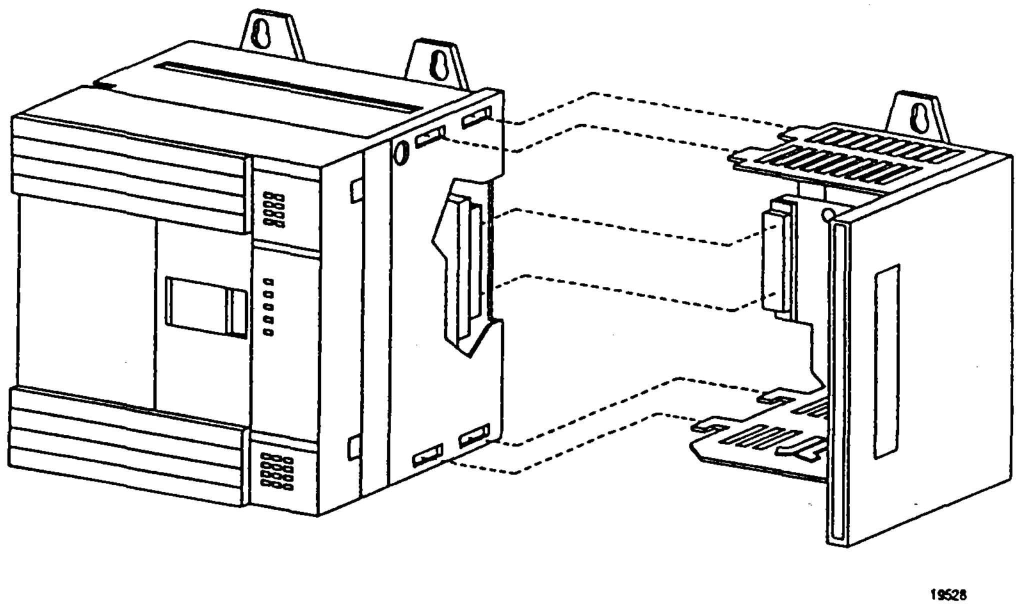
Mounting the 2–Slot Expansion Chassis

The expansion chassis mounts on the right side of the fixed controller. The chassis has mounting tabs that are inserted into slots in the fixed controller and slid forward. No tools are required.

1. Insert the mounting tabs of the expansion chassis into the mounting slots of the controller.



2. Slide the expansion chassis forward until the back of the expansion chassis is flush with the fixed controller and the connector on the expansion circuit board is mated with the connector in the controller.



Installing I/O and Speciality Modules

With the 2–slot expansion chassis on the fixed style unit, additional I/O and specialty modules can be supported.

ATTENTION: Never install, remove, or wire modules with power applied to the chassis.

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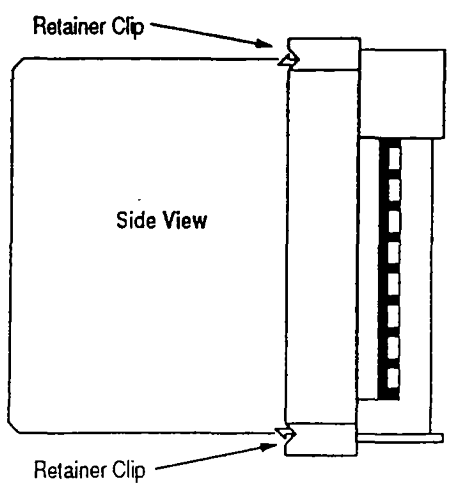
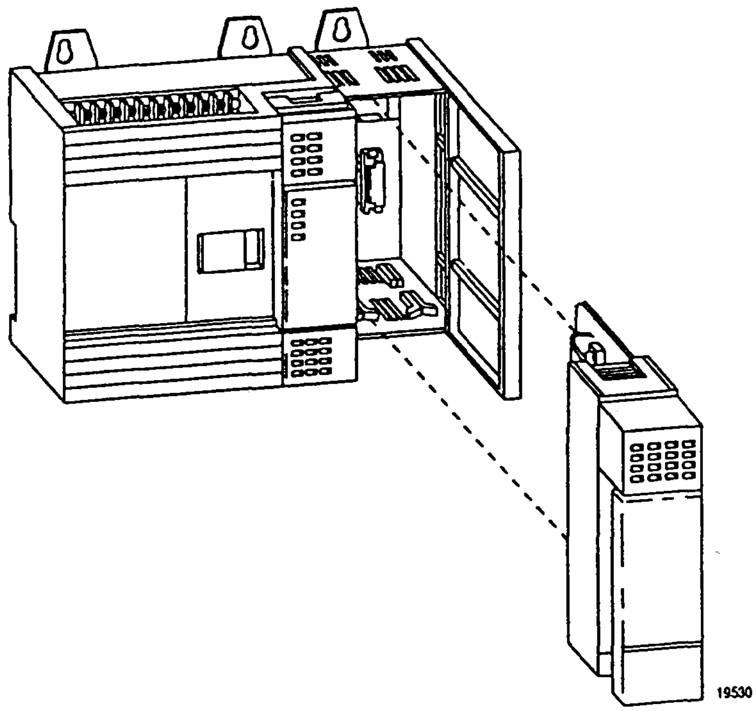
1. Align circuit board of the module with card guide in chassis.



2. Gently slide the module in until both top and bottom retainer clips are secured.



3. To remove the module, press the retaining clips at the top and bottom of the module and slide the module out.

Installing Your Memory Module

Always turn off power to the controller before inserting or removing the memory module. This guards against possible damage to the module and also undesired processor faults. Memory modules are mounted in carriers and have connectors that are "keyed" to guard against improper installation.

ATTENTION: To avoid potential damage to the memory modules, handle them by the ends of the carrier or edges of the plastic housing. Skin oil and dirt can corrode metallic surfaces, inhibiting electrical contact. Also, do not expose memory modules to surfaces or areas that may hold an electrostatic charge. Electrostatic charges can alter or destroy memory.

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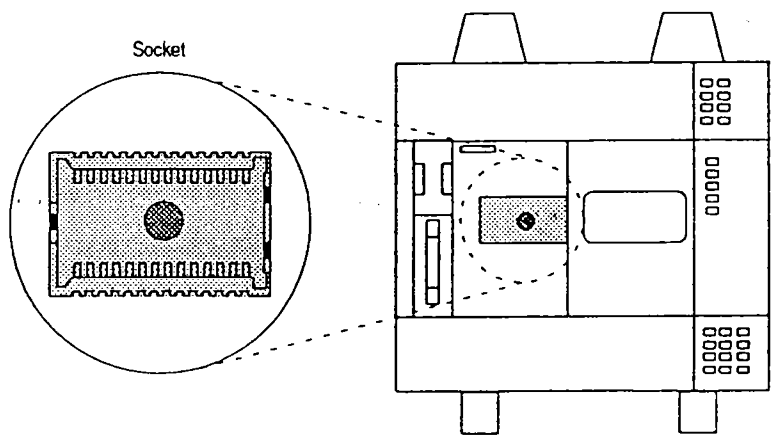
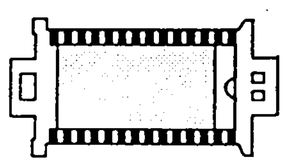
1. Always turn off power to the controller before inserting or removing the memory module. This guards against possible damage to the module and also undesired processor faults.
2. Remove the processor compartment cover.
3. Locate the socket on the PC board.



4. Position the module correctly over the socket and press it firmly in place. (The memory module is keyed.)


1747-M1, -M2, -M3

5. Replace the cover on the SLC controller and restore power.

Removing Your Memory Module

To remove a memory module use the following procedure:

1. Remove the power from the fixed I/O unit.
2. Remove the processor compartment cover.
3. Grasp the carrier tabs with the thumb and index fingers, then gently but firmly lift upwards on either end of the memory module carrier.
4. When the end is partially raised, begin lifting the other end in the same manner. Repeat this until the memory module has been completely removed from the socket.
5. Replace processor cover.

Using the High–Speed Counter

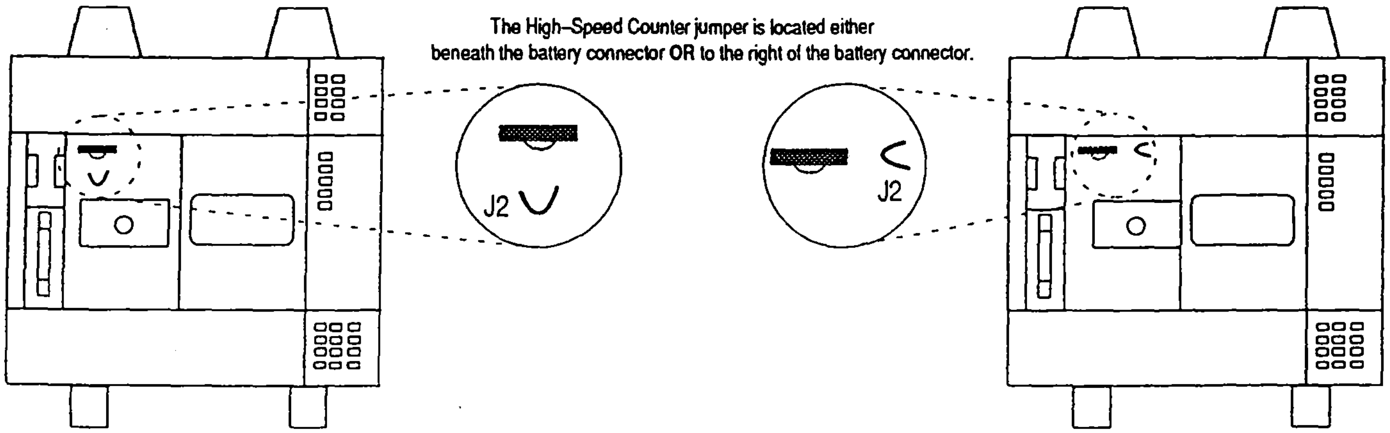
The fixed I/O units that have 24 VDC input circuits are also equipped with a high–speed counter. The counter is capable of counting at a rate of up to 8 kHz.

You have the option of using input 0 as a normal input or as a high–speed counter. To accommodate this dual function the input is equipped with a jumper selectable filter. You must cut the jumper for high–speed counter use. A shielded cable is recommended to reduce noise to the input.

High–Speed Counter Operation

For high–speed counter operation do the following:

1. Turn off power to the fixed controller.
2. Remove the SLC 500 cover.
3. Locate and cut jumper wire J2. The jumper is either beneath or to the right of the battery connector, as shown below. Do not remove completely but make certain that the ends of the cut jumper wire are not touching each other.



4. Replace the cover.

High–Speed Counter Input Compatibility

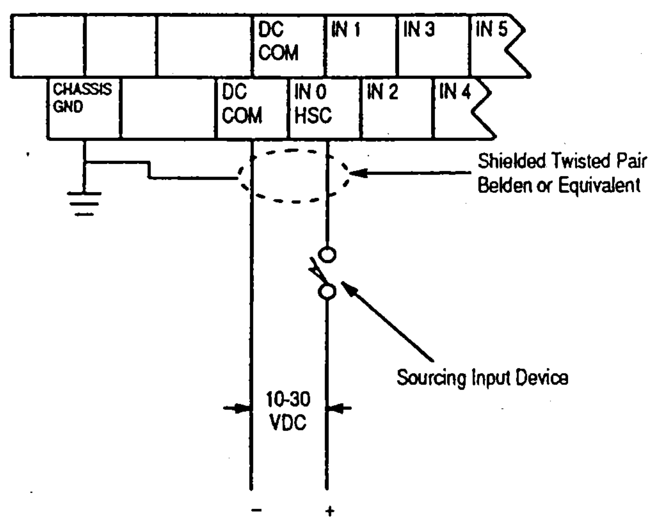
The high–speed counter input circuit has the following characteristics:

- nominal input impedance of ≈ 1200 Ω
- on–state voltage of 10–30 VDC
- nominal input current draw of 20mA
- minimum pulse width of 62.5 µsec.

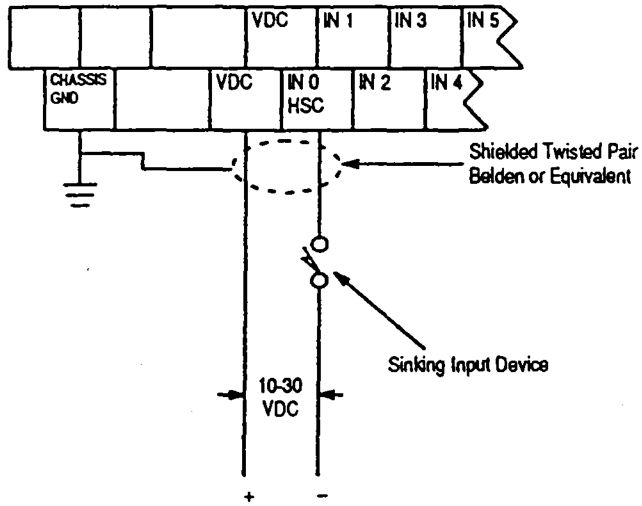
Your input device or encoder must be single–ended and be compatible with the specifications of the high–speed counter input. See the table below for more information.

For an Input Device or Encoder that Is	Use an HSC Input Circuit that Is
Sourcing	Sinking
Open Collector/ Sinking	Sourcing
Open Collector with Pull–up Resistor	Sinking

Wiring Diagram of a High–Speed Counter Sinking Input Circuit



Wiring Diagram of a High–Speed Counter Sourcing Input Circuit



Chapter 5

Wiring Your Control System

This chapter describes how to wire your I/O modules. It covers the following:

- defining sinking and sourcing
- determining approximate transient duration
- preparing your wiring layout
- features of an I/O module
- recommendations for wiring I/O devices
- wiring your I/O modules
- using Removable Terminal Blocks (RTBs)

Defining Sinking and Sourcing

Sinking and sourcing are terms used to describe a current signal flow relationship between field input and output devices in a control system and their power supply.

- Field devices connected to the positive side (+V) of the field power supply are sourcing field devices.
- Field devices connected to the negative side (DC Common) of the field power supply are called sinking field devices.

To maintain electrical compatibility between field devices and the programmable controller system, this definition is extended to the input/output circuits on the discrete I/O modules.

- Sourcing I/O circuits supply (source) current to sinking field devices.
- Sinking I/O circuits receive (sink) current from sourcing field devices.

Contact Output Circuits — AC or DC

Relays can be used for either AC or DC output circuits and accommodate either sinking or sourcing field devices. These capabilities are a result of the output switch being a mechanical contact closure, not sensitive to current flow direction and capable of accommodating a broad range of voltages.

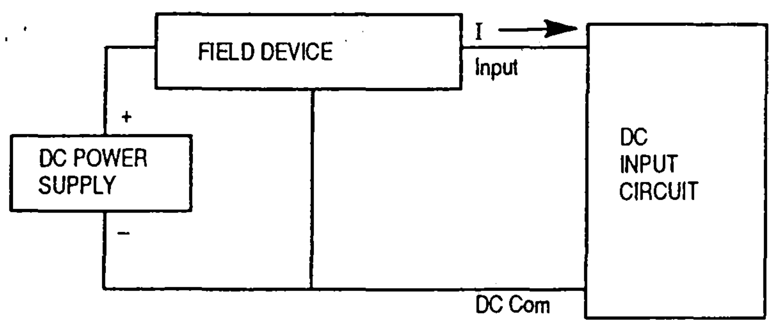
This high degree of application flexibility makes contact output modules very popular and useful in control environments with a broad mix of electrical I/O circuit requirements.

Solid–State DC I/O Circuits

The design of DC field devices typically requires that they be used in a specific sinking or sourcing circuit depending on the internal circuitry of the device.

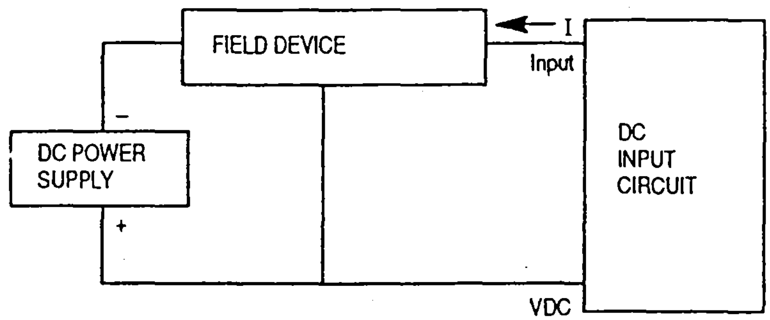
Sourcing Device with Sinking Input Module Circuit

The field device is on the positive side of the power supply between the supply and the input terminal. When the field device is activated, it sources current to the input circuit.



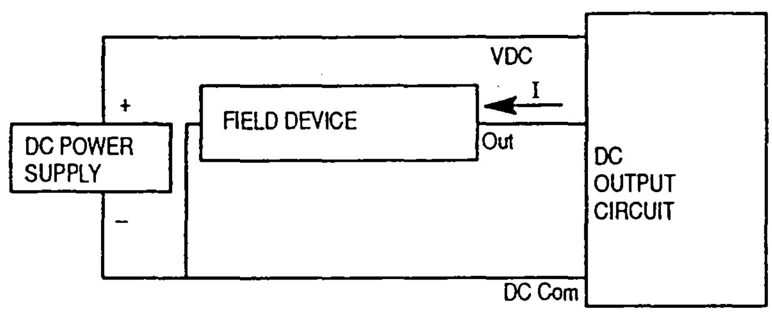
Sinking Device with Sourcing Input Module Circuit

The field device is on the negative side of the power supply between the supply and the input terminal. When the field device is activated, it sinks current from the input circuit.



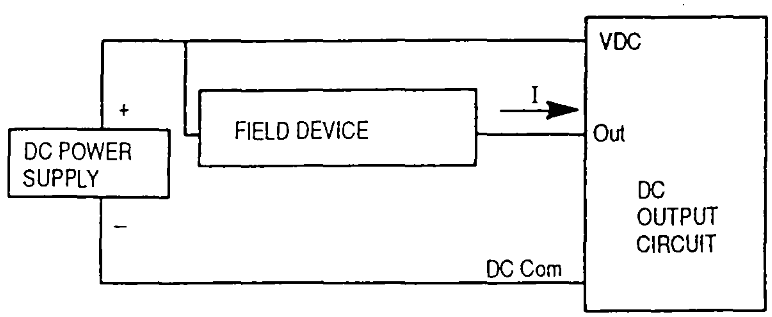
Sinking Device with Sourcing Output Module Circuit

The field device is on the negative side of the power supply between the supply and the output terminal. When the output is activated, it sources current to the field device.



Sourcing Device with Sinking Output Module Circuit

The field device is on the positive side of the power supply between the supply and the output terminal. When the output is activated, it sinks current from the field device.



Preparing Your Wiring Layout

Careful wire routing within the enclosure helps to cut down electrical noise between I/O lines. Follow these rules for routing your wires:

- Route incoming power to the controller by a separate path from wiring to I/O devices. Where paths must cross, their intersection should be perpendicular.

  Important: Do not run signal or communications wiring and power wiring in the same conduit.

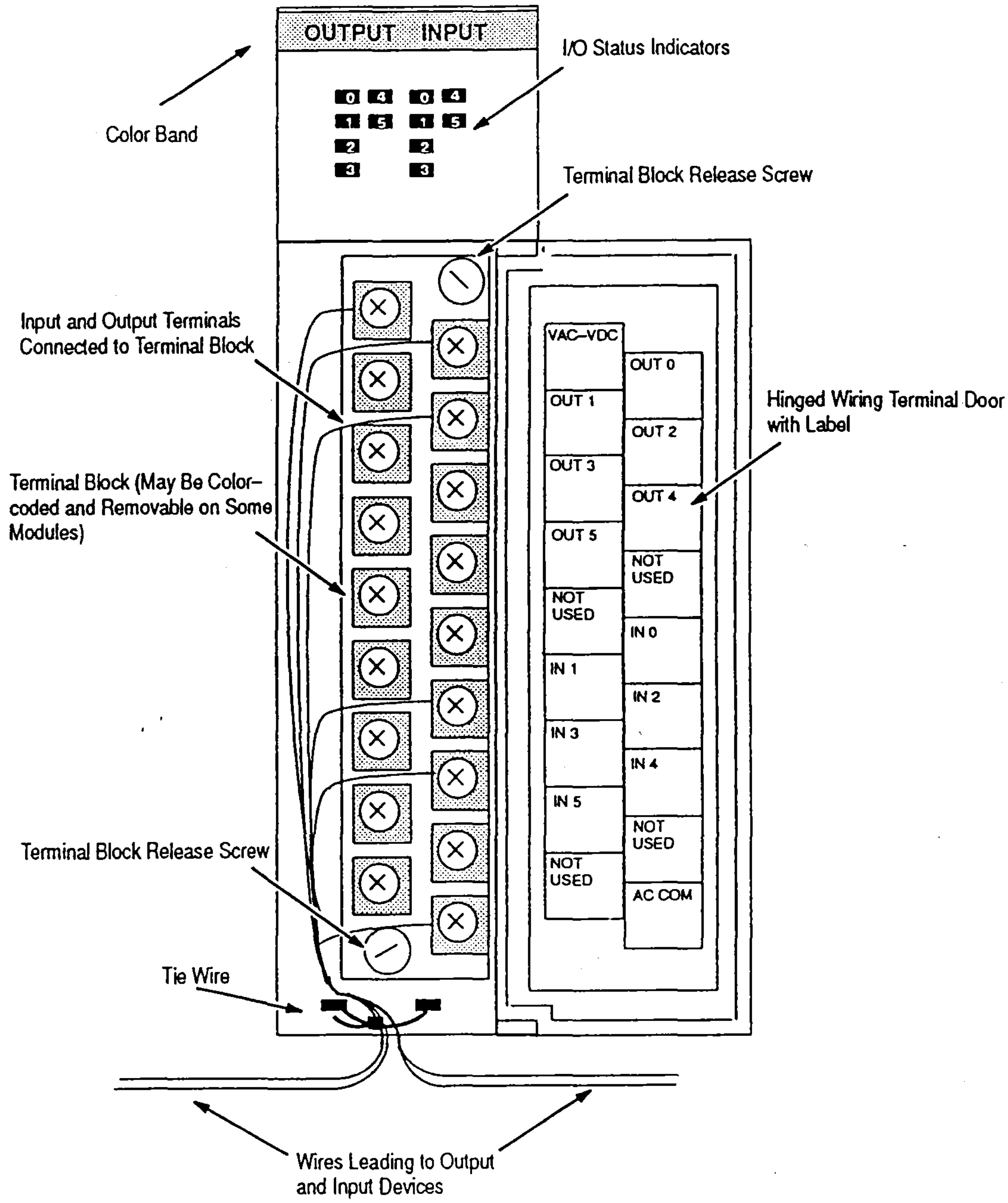
- If wiring ducts are used, allow for at least two inches between I/O wiring ducts and the controller. If the terminal strips are used for I/O wiring, allow for at least two inches between the terminal strips and the controller.
- Segregate I/O wiring by signal type. Bundle wiring with similar electrical characteristics together.

Wires with different signal characteristics should be routed into the enclosure by separate paths.

ATTENTION: If the controller is being installed within a potentially hazardous environment (that is, Class I, Division 2), all wiring must comply with the requirements stated in the National Electrical Code 501–4 (b).

Features of an I/O Module

Below is an example of a combination I/O module.



Recommendations for Wiring I/O Devices

The following are general recommendations for wiring I/O devices.

ATTENTION: Before you install and wire I/O devices, disconnect power from the controller and any other source to the I/O devices.

Use acceptable wire gauge — The I/O wiring terminals are designed to accept #14 or smaller AWG stranded wires, and two wires per terminal (maximum). Maximum torque 0.9 N–m (8 in–lb).

Label wires — Label wiring to I/O devices, power sources, and ground. Use tape, shrink–tubing, or other dependable means for labeling purposes. In addition to labeling, use colored insulation to identify wiring based on signal characteristics. For example, you may use blue for DC I/O wiring and red for AC I/O wiring.

Bundle wires — Bundle wiring for each similar I/O device together. If you use ducts, allow at least 5 cm (2 in.) between the ducts and the controller so there is sufficient room to wire the devices.

Identify terminals — Terminal cover plates have a write–on area for each terminal. Use this area to identify your I/O devices. Label the Removable Terminal Block (RTB) with appropriate slot, rack (chassis) and module identification if you have not already. Refer to page 5–8 for more information.

ATTENTION: Calculate the maximum possible current in each power and common wire. Observe all local electrical codes dictating the maximum current allowable for each wire size. Current above the maximum ratings may cause wiring to overheat, which can cause damage.

Capacitors on input modules have a stored charge that can cause a non–lethal shock. Avoid mounting the controller in a position where installation or service personnel would be in danger from startle reaction.

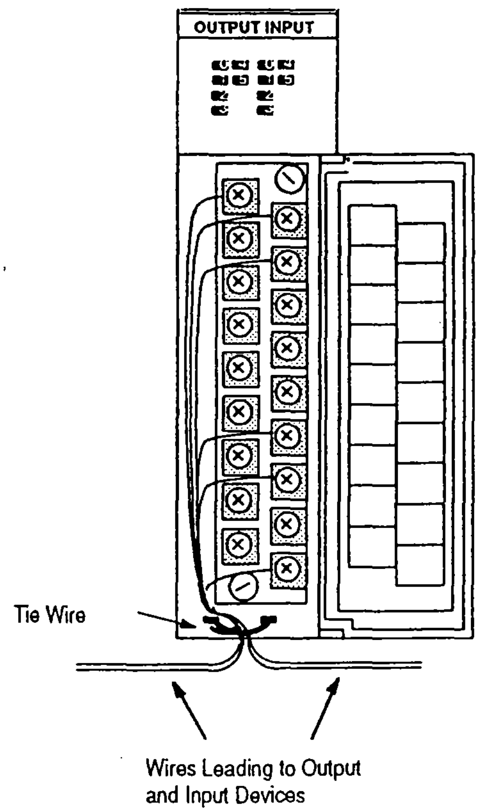
Wiring Your I/O Modules

Terminals on the modules have self–lifting pressure plates that accept two #14 AWG wires. Series B 12–point and 16–point and analog modules are equipped with removeable terminal blocks (RTBs) for ease of wiring. For more information on using RTBs, see the next section.

LED indicators on the front of each module display the status of each I/O point. The LED indicators turn on when the proper signal to an input terminal is applied or when the processor commands an output to be energized.

To locate the I/O module wiring diagrams, contact your Allen–Bradley sales office for the latest product data entitled *Discrete Input and Output Modules*, Publication Number 1746–2.35. Or, locate the installation instruction sheet that was sent with your I/O module; it also includes I/O wiring diagrams.

1. Install a wire tie to secure your wiring and keep it neat. (If you feed the tie into one hole, it will be routed back out through the other.)



2. Cover any unused slots with card slot fillers, Catalog Number 1746–N2, to keep the chassis free from debris and dust.

Using Removable Terminal Blocks (RTBs)

Removable Terminal Blocks (RTBs) are provided on all 12–point and 16–point discrete I/O modules and analog modules. RTBs can only be used with these modules in the 2–slot expansion chassis. RTBs allow for faster and more convenient wiring of the I/O modules. The modules and RTBs are color–coded as follows:

Color	Type of I/O Removable Terminal Block
Red	AC inputs/outputs
Blue	DC inputs/outputs
Orange	relay outputs
Green	specialty modules

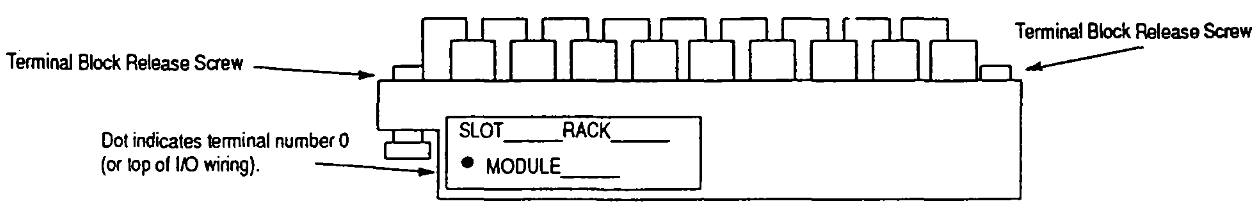
Replacement terminal blocks are available if they are lost or damaged. See the replacement part list in chapter 9.

Removing RTBs

Below are guidelines for removing the I/O RTBs.

ATTENTION: Never install or remove I/O modules or terminal blocks while the SLC is powered.

1. If the I/O module is already installed in the chassis, remove power to the SLC.
2. Unscrew the upper right and lower left terminal block release screws.
3. Grasp the RTB with your thumb and forefinger and pull straight out.
4. Label the RTB with appropriate slot, rack (chassis) and module identification.



Installing RTBs

Below are guidelines for installing the I/O RTBs.

1. Label the RTB properly.
2. Match the label identification to the correct chassis, slot, and module type.

ATTENTION: Inserting a wired RTB on an incorrect module can damage the I/O module circuitry when power is applied.

3. Be sure the color band on the I/O module matches the color of the RTB.

ATTENTION: Never install or remove I/O modules or RTBs while the SLC 500 chassis is powered.

4. Remove power from the SLC 500 chassis.
5. Line up terminal block release screws.
6. Press the RTB firmly onto connector contacts.
7. Tighten the RTB release screws.

Chapter 6

Starting Up Your Control System

This chapter describes how to start up your control system. To accomplish this, you must go through eight procedures.

Procedures for Starting Up the Control System

Start–up involves the following procedures to be carried out in sequence:

1. Inspect your installation.
2. Disconnect motion–causing devices.
3. Initialize and test your processor.
4. Test your inputs.
5. Test your outputs.
6. Enter and test your program.
7. Observe control motion.
8. Conduct a dry run of your application.

These procedures isolate problems such as wiring mistakes, equipment malfunction, and programming errors in a systematic, controlled manner.

We urge you to go through these procedures very carefully. This will help you avoid possible personal injury and equipment damage.

Important: Do not attempt system start–up until you are thoroughly familiar with the controller components and programming/editing techniques. You must also be thoroughly familiar with the particular application.

For general recommendation concerning installation safety requirements and safety requirements and safety related work practices, refer to NFPA 70E, *Electrical Safety Requirements for Employee Workplaces*.

1. Inspect Your Installation

You can often prevent serious problems in later test procedures by first making a thorough physical inspection. We recommend that you do the following:

1. Make sure that the controller and all other devices in the system are securely mounted. Refer to chapter 3 and chapter 4 for more information.
2. Check all wiring including:
   - connections from the main disconnect to the controller input
   - the master control relay/emergency–stop circuit
   - input device circuits
   - output device circuits

   Make certain that all wiring connections are correct and that there are no missing wires. Check the tightness of all terminals to make certain wires are secure. Refer to chapter 5 for more information.
3. Measure the incoming line voltage. Be certain that it corresponds to controller requirements and that it falls within the specified voltage range. See specifications for input voltage ranges in chapter 1.

2. Disconnect Motion–causing Devices

In the following test procedures, the controller will be energized. As a safety precaution, you must make certain that machine motion will not occur. The preferred way is to disconnect the motor wires at the motor starter or the motor itself. In this way, you can test the operation of the starter coil, verifying that your output circuit is wired correctly and functioning. Similarly, the preferred way to disconnect a solenoid is to disengage the valve, leaving the coil connected.

In some instances, you may not be able to disconnect a device the preferred way. In this case, it will be necessary to open the output circuit at some convenient point.

For circuit testing purposes, it is best to open the circuit at a point as close as possible to the motion–causing device. For example, your output might be a relay coil that in turn energizes a motor starter; if it is impractical to disconnect the motor wires, the next best thing to do is to open the circuit at a point between the motor starter and the relay contact.

ATTENTION: Machine motion during system checkout can be hazardous to personnel. During the checkout procedures 3, 4, 5, and 6, you must disconnect all devices that, when energized, might cause machine motion.

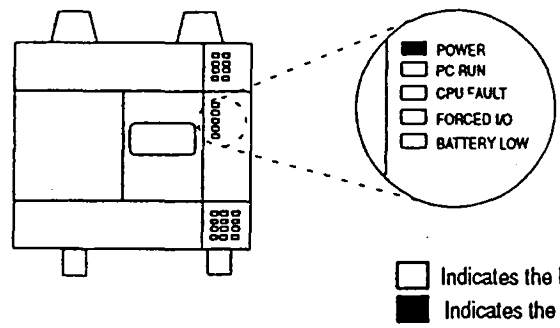
---

3. Initialize and Test Your Processor

When you are certain that machine motion cannot occur with the controller energized, you may begin by initializing the processor using the following steps:

1. Energize the controller. If power is supplied to the controller and the installation is correct, then:

   A. The POWER LED turns on as shown in the figure below.



   The CPU FAULT LED also turns on during power–up, but it should go off after a few seconds. If instead this LED starts flashing, it indicates you must clear the processor memory before continuing.

   B. The following processor initial factory conditions apply:
   - Mode = PROGRAM MODE (S:1/0 – S:1/4 = 0 0001)
   - Watchdog values = 100ms (S:3H = 0000 1010)
   - I/O Slot enables = ALL ENABLED (S:11/1 through S:12/14 set to 1)
   - Node address = 1 (S:15L = 0000 0001)
   - Baud Rate = 19.2K baud (S:15H = 0000 0100)
   - Processor Name = DEFAULT

2. Power up the programming device.

   Refer to the *Hand-Held Terminal User Manual,* Catalog Number 1747–NP002, for information on programming your fixed controller with the HHT.

   Refer to the *Advanced Programming Software User Manual,* Catalog Number 1747–NM002 Series C, and the *Advanced Programming Software Reference Manual,* Catalog Number 1747–NR001, for information on programming your fixed controller with APS.

3. Configure the controller.
4. Name the processor file.
5. Program a sample test rung not affecting machine operation.
6. Save the program and the controller configuration.

7. Transfer the controller configuration and the sample test program to the processor. After the new program is transferred to the processor, the processor fault status should clear. (The CPU FAULT LED stops if it was flashing.)
8. Enter the Run mode.

   The processor PC RUN LED should turn on indicating the controller is in the RUN mode with no processor faults. If any other processor status exists, refer to chapter 8.
9. Monitor the sample test rung.

   If the sample test rung operates successfully without processor faults, you have verified that basic processor functions are properly functioning. If any other processor status exists, refer to chapter 8.

4. Test Your Inputs

After successful processor initialization and test, you may begin testing inputs following these steps:

1. Assuming you are still online with the programming device, put the controller into the Continuous Test mode. This allows the processor to scan the I/O and program, but not turn on any physical outputs.
2. Monitor the data in data File 1, the input data file. All configured inputs should be displayed.
3. Make sure the first input slot, slot 0, is shown on the monitor.
4. Select the first input device connected to Input 0 of the fixed I/O chassis.
5. Manually close and open the addressed input device.

ATTENTION: Never reach into a machine to actuate a device, unexpected machine operation could occur.

---

6. Observe the associated bit status using the programming device monitor function. Also, observe the input status LED on the fixed I/O chassis.

   A. When the input device is closed verify that the voltage at the input terminal is within the specified on–state range, the input status LED is on, and the associated status bit is set to a one.

      If any of these conditions are not satisfied, follow the recommended troubleshooting steps listed below.

   B. When the input device is opened verify that the voltage at the input terminal is within the specified off–state range, the input status LED is off, and the associated status bit is reset to 0.

      If any of these conditions are not satisfied, follow the recommended troubleshooting steps listed below.

7. Select the next input device and repeat steps 5 and 6 until all inputs on the fixed I/O chassis and in the 2–slot expansion rack (if used) have been tested.

Input Troubleshooting Steps

1. Make sure the processor is in the Continuous Test mode.
2. Verify that your inputs and outputs are enabled. Status file bit S:11/0 represents the inputs and outputs of the fixed controller. Status file bits S:11/1 and S:11/2 represent the inputs and outputs (slot 1 and slot 2 respectively) of the 2–slot expansion chassis. These bits must be set to one, enabling all your inputs and outputs.
3. Check your wiring and verify that all connections are tight.

   A. Make sure that power connections have been made to your input device if needed.

   B. Verify that the signal connection has been made from the input device to the correct input circuit of the fixed controller.

   C. Check that all common connections have been made.

4. Check your specifications.

   A. Make sure that the power is within the specified voltage range if your input device requires power.

   B. Verify that your power supply is not overloaded. An overloaded supply can deliver the correct voltage when some of its loads are not energized but the voltage may fall out of range when all of its loads are energized.

   C. Verify that your input device signal contact is specified to deliver sufficient current to the input circuit and any other loads connected to it.

   D. Make certain that your input device does not have a minimum load specification that is greater than the input circuit current specification.

   E. Verify that the input device is on and off longer than the specified turn–on and turn–off times for the input circuit.

5. Disconnect your input devices from the fixed controller input terminals. Make a direct connection from a power supply to the fixed controller input and common terminals. The power supply voltage must be within the specified on–state voltage range of the input circuit. If you can energize and de–energize the input circuit by turning the power supply on and off, the basic operation of the input circuit is functioning correctly. The problem is likely to be with the input device or wiring. If you cannot operate the the input circuit by a direct connection, the input circuit is not functioning and should be replaced.
6. Connect a different load to your input device. Open and close the input device and measure the voltage at the load. If your input device cannot operate other loads, the input device is not functioning properly and should be replaced.

For more information on input troubleshooting, see page 8–8.

5. Test Your Outputs

After you test all inputs, and have determined that they are functioning properly, test the outputs following these steps.

1. Refer to page 6–2 to insure that no motion will occur when any controller output is energized.
2. Place the controller in the Program mode.
3. Create an output test rung as shown below for each output slot configured. Enter your source and destination address:

Here "X" represents the slot number of the output currently selected. This rung moves a word of data from the bit file to the output file. The slot number is 0 for outputs of the fixed controller. If the 2–slot expansion chassis is used, numbers one and two are used for the outputs in slots 1 and 2 respectively.

4. Save the output test program and controller configuration.
5. Transfer the output test program to the processor.
6. Put the controller in the Run mode.
7. Monitor the data in bit file B3 on the programming device display.
8. Enter `B3: "X"` at the address prompt to select the output slot to be tested.
9. Move the cursor to the bit position that corresponds to the specific output being tested. Set the bit to 1.

10. Observe the output status LED and the output device.

    The output status LED should turn on. The output device should be energized unless you disconnected it to prevent machine motion. It may be necessary to connect a dummy load to the output to complete this test. If the LED does not turn on or if the load is not energized, follow the output troubleshooting steps listed below.

11. Reset the bit value back to zero for the selected address. Both the output status LED and the output device should de–energize. If the LED does not turn off or if the load does not de–energize, follow the output troubleshooting steps listed below.

12. Repeat steps 9 through 11 for all outputs of the selected slot.

13. Repeat steps 8 through 12 for all slots (with outputs) that are a part of the fixed controller configuration.

Output Troubleshooting Steps

1. Make sure the processor is in the Run mode.

2. Verify that the test rung recommended in the previous section has been entered correctly.

3. Check the status file I/O slot enable bits. Status file bit S:11/0 represents the inputs and outputs of the fixed controller. Status file bits S:11/1 and S:11/2 represent the inputs and outputs (slot 1 and slot 2 respectively) of the 2–slot expansion chassis. These bits must be set to one, enabling all your inputs and outputs.

4. Use a programming device to verify that the bit being tested in the output file tracks the on/off status of the corresponding bit in the bit file.

   If the output file does not track the bit file, but your program has been entered correctly and the I/O are enabled, then your processor is not functioning properly and should be replaced.

   If the output file tracks the bit file, then the processor is functioning properly and the output command is being sent to either the I/O section of the fixed controller, or to the output module in the 2–slot expansion chassis.

5. Check the electrical connections.

   A. If the output being tested is in the 2–slot expansion chassis, verify that the expansion chassis connector is properly mated to the expansion connector of the fixed controller.

   B. Turn off power to the I/O circuits. Verify that power and/or common connections are made to the proper output circuit terminals.

   C. Verify that the power connections are made to the output load device if they are required.

   D. Verify that the output terminal being tested is connected to the correct termination point of the load device.

   E. Check the tightness of all terminals to make certain that all wires are secure.

6. Check your specifications.

   A. Verify that all power supplies used are within the specified operating ranges of the I/O circuits and loads.

   B. Check that the specified load current is greater than the minimum load current specified for the output circuit. (Leakage current from the output circuit may prevent you from turning off a low current load.)

   C. Check that the specified load current is less than the maximum load current of the output circuit.

   D. Make sure that the sum of all the load currents is equal to or less than the power supply capacity.

7. Restore power to the I/O circuits and test the output. If the preceding measures have not corrected the problem, turn off the I/O power and disconnect the load. Connect the load directly to the I/O power supply. You should be able to operate the load by turning the power supply on and off.

   If you can operate the load, and the load is within the specified operating range of the output circuit, the output circuit is not functioning properly. Replace the fixed controller or output module as necessary.

   If you cannot operate the load by turning the power supply on and off, the load is not operating properly and it should be replaced.

For more information on output troubleshooting, refer to page 8–10.

6. Enter and Test Your Program

After you test all inputs and outputs and they are functioning properly, we recommend the following steps to safely and successfully enter and test your specific application program. (For extra assistance, see the *Hand–Held Terminal User Manual* or the *Advanced Programming Software User Manual.*)

1. Verify the offline program.

   After the program has been entered in the offline edit file mode, program verification may begin.

   Remaining in the offline edit file mode you may use the cursor keys and/or search function of your programming device to inspect every instruction and rung for errors.

2. Check your written program, rung for rung, against the program entered into the offline memory. The most common errors found in program entry are:

   - incorrect addressing of instructions
   - omission of an instruction
   - more than one output instruction programmed using the same address

3. Transfer the program into the processor.

   A. Place your programming device online.

   B. Place the processor in Program mode.

   C. Select download function when using the Hand–Held Terminal or the restore function when using Advanced Programming Software.

4. Verify the online program transfer.

   A. Select monitor file function.

   B. Cursor through the program to verify that you selected the right program.

5. Conduct a single–scan program test.

   A. Select the monitor file function and place the cursor on the first rung.

   B. Select the Test mode.

   C. Select Single–Scan (SSN) test. In this test mode, the processor executes a single operating cycle, which includes reading the inputs, executing the ladder program, and updating all data without energizing the output circuits. However, the monitor file function will identify the output status as if the outputs were enabled.

      Timers are also incremented a minimum of 10 milliseconds each single scan.

   D. Simulate the input conditions necessary to execute the current monitored rung of the program. If it is not practical to manually activate the input device, use the force function to simulate the proper condition.

ATTENTION: Never reach into a machine to actuate a device, unexpected machine operation could occur.

   E. Activate a single operating scan as outlined in the programming device user manual.

   F. Verify the intended effects on the output instructions for that rung and overall program logic effects.

   G. Select the next program rung and repeat test procedures as listed above until the entire program has been tested.

6. Conduct a continuous scan program test.

   Once the individual single scan rung tests have been completed and proper program operation verified, a continuous scan test might be appropriate before motion checkout.

   This mode simulates the controller Run mode without energizing the external outputs.

7. Observe Control Motion

Now that program execution has been verified, checkout of control motion can begin. All persons involved with the programming, installation, layout design, machine or process design, and maintenance should be involved in making decisions for determining the best and safest way to test the total system.

The following procedures are general in nature. Individual conditions may warrant their modification. The basic approach is to initiate testing with the least amount of machine motion. Only some outputs are allowed to generate machine motion. Then additional machine motion can be gradually added, thereby allowing any problems to be detected more easily under controlled conditions. The following procedure provides the steps for testing machine motion using one output at a time.

ATTENTION: During all phases of checkout, station a person ready to operate an emergency–stop switch if necessary. The emergency–stop switch will de–energize the master control relay and remove power from the machine. This circuit must be hardwired only, it *must not* be programmed.

Use the following procedures:

1. Identify the first output device to be tested and reconnect its wiring.

ATTENTION: Contact with AC line potential may cause injury to personnel. When reconnecting wiring, make sure that AC power disconnect switch is opened.

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2. Place the controller in the Run mode and observe the behavior of the output device. To do this, simulate the input conditions necessary to energize the output in the program. If it is not practical to manually activate an input device, use the force function to simulate the proper input condition.

ATTENTION: Never reach into a machine to actuate a device, unexpected machine operation could occur.

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3. Repeat steps 1 and 2, testing each output device, one at a time.

8. Conduct a Dry Run

ATTENTION: During all phases of the dry run test, station a person ready to operate an emergency–stop switch if necessary. The emergency–stop switch will de–energize the master control relay and remove power from the machine. This circuit must be hardwired only, it *must not* be programmed.

After thoroughly checking out the controller system and program, proceed with a dry run of the application with all of the output devices enabled. This dry run will vary with the application. For example, a machine tool dry run might test the program with all outputs enabled but without tooling an actual part.

After you check out the entire system, and your dry run has been completed satisfactorily, we recommend that you load your program into an EEPROM memory module for back–up program storage. See chapter 3 for more information. Refer to the *Hand–Held Terminal User Manual,* Catalog Number 1747–NP002, or the *Advanced Programming Software User Manual,* Catalog Number 1747–NM002, for directions on loading the EEPROM from RAM.

This step completes the start–up procedures. Your SLC Programmable Controller is now ready for operation.

Chapter 7

Maintaining Your Control System

This chapter covers the following:

- handling, storing, and transporting battery, Catalog Number 1747–BA
- installing or replacing your SLC 500 battery
- replacing the power supply fuse
- replacing retainer clips on a module

Refer to chapter 2 for important information on testing the master control relay circuit and preventive maintenance.

Handling, Storing, and Transporting Battery, Catalog Number 1747–BA

Follow the procedure below to ensure proper battery operation and reduce personnel hazards.

Handling

- Use only for the intended operation.
- Do not ship or dispose of batteries except according to recommended procedures.
- Do not ship on passenger aircraft.

ATTENTION: Do not charge the batteries. An explosion could result or they could overheat causing burns.

Do not open, puncture, crush, or otherwise mutilate the batteries. A possibility of an explosion exists and/or toxic, corrosive, and flammable liquids would be exposed.

Do not incinerate or expose the batteries to high temperatures. Do not attempt to solder batteries. An explosion could result.

Do not short positive and negative terminals together. Excessive heat could build up and cause severe burns.

Storing

Store the lithium batteries in a cool, dry environment, typically +20° C to +25° C (+68° F to +77° F) and 40% to 60% relative humidity. Store the batteries and a copy of the battery instruction sheet in the original container, away from flammable materials.

Transporting

One or Two Batteries – Each battery contains 0.23 grams of lithium. Therefore, up to two batteries can be shipped together within the United States without restriction. Regulations governing shipment to or within other countries may differ.

Three or More Batteries – Procedures for the transportation of three or more batteries shipped together within the United States are specified by the Department of Transportation (DOT) in the Code of Federal Regulations, CFR49, "Transportation." An exemption to these regulations, DOT – E7052, covers the transport of certain hazardous materials classified as flammable solids. This exemption authorizes transport of lithium batteries by motor vehicle, rail freight, cargo vessel, and cargo–only aircraft, providing certain conditions are met. Transport by passenger aircraft is not permitted.

A special provision of DOT–E7052 (11th Rev., October 21, 1982, par. 8–a) provides that:

> "Persons that receive cell and batteries covered by this exemption may reship them pursuant to the provisions of 49 CFR 173.22a in any of these packages authorized in this exemption including those in which they were received."

The Code of Federal Regulations, 49 CRF 173.22a, relates to the use of packaging authorized under exemptions. In part, it requires that you must maintain a copy of the exemption at each facility where the packaging is being used in connection with shipment under the exemption.

Shipment of depleted batteries for disposal may be subject to specific regulation of the countries involved or to regulations endorsed by those countries, such as the IATA Restricted Articles Regulations of the International Air Transport Association, Geneva, Switzerland.

Important: Regulations for transportation of lithium batteries are periodically revised.

ATTENTION: Do not incinerate lithium batteries in general trash collection. Explosion or violent rupture is possible. Batteries should be collected for disposal in a manner to prevent against short circuiting, compacting, or destruction of case integrity and hermetic seal.

For disposal, batteries must be packaged and shipped in accordance with transportation regulations, to a proper disposal site. The U.S. Department of Transportation authorizes shipment of "Lithium batteries for disposal" by motor vehicle only in regulation 173.1015 of CRF49 (effective January 5, 1983). For additional information contact:

U.S. Department of Transportation
Research and Special Programs Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

Although the Environmental Protection Agency at this time has no regulations specific to lithium batteries, the material contained may be considered toxic, reactive, or corrosive. The person disposing of the material is responsible for any hazard created in doing so. State and local regulations may exist regarding the disposal of these materials.

Installing or Replacing Your SLC 500 Battery

Back–up power for RAM is provided by a capacitor that will retain the contents of the RAM for a period of 5 to 30 days. For applications requiring memory back–up for a longer period of time an optional replaceable battery, Catalog Number 1747–BA, is required. The lithium battery provides back–up for approximately five years. A red BATTERY LOW LED turns on when the battery voltage has fallen below a threshold level.

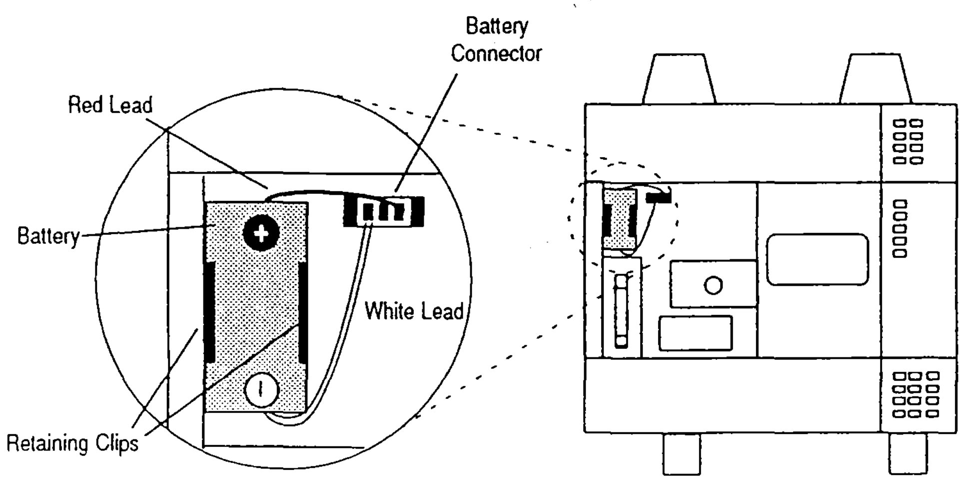
Once the BATTERY LOW LED goes on, do *not* remove processor power or your program may be lost. Replace the battery as soon as possible. You can replace the battery while the processor is powered.

For battery installation or replacement do the following:

1. Remove the processor cover.
2. If you are:

   installing a battery in a new processor (battery never installed before), remove the jumper from the battery socket. Store jumper in safe place for possible future use without battery.

   replacing an old battery, unplug the battery connector from the socket. The figure below shows you where to install the battery in a fixed controller.
3. Insert a new or replacement battery in the holder making sure it is held in by the retaining clip.
4. Plug the battery connector into the socket. See the figure below.



5. Replace the cover.

Replacing the Power Supply Fuse

Under normal power–up conditions, the POWER LED turns on. If a power supply fuse is blown, the POWER LED will not turn on. One of the following conditions could cause a blown power supply fuse:

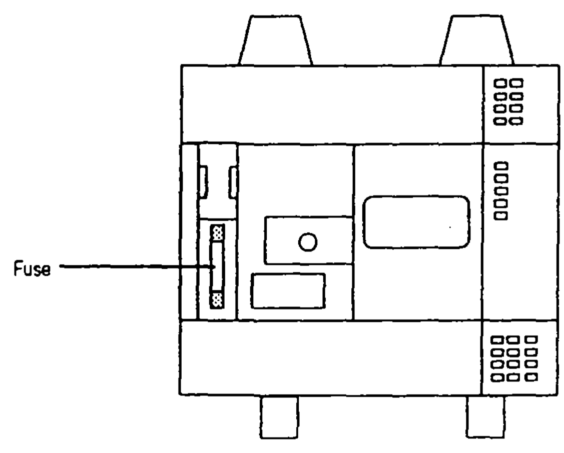
- excessive line voltage
- internal power supply malfunction
- overloading 2–slot chassis

ATTENTION: Contact with AC line potential can cause injury to personnel. Remove system power before attempting fuse replacement.

Use only replacement fuses of the type and rating recommended for the unit. Improper fuse selection can result in equipment damage.

After the conditions causing the malfunction have been corrected, you can replace the fuse:

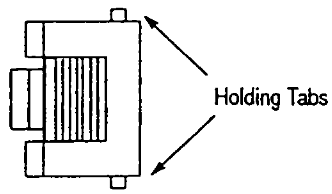
1. Disconnect power to the processor.
2. Remove the cover on the processor.
3. Locate the fuse. Use a miniature fuse puller to grip the fuse and remove it from its holder.
4. Discard the fuse and replace it with the recommended replacement fuse. (See chapter 9 for more information.)



5. Replace the cover on the processor.
6. Restore power to the processor. The POWER LED should now turn on.

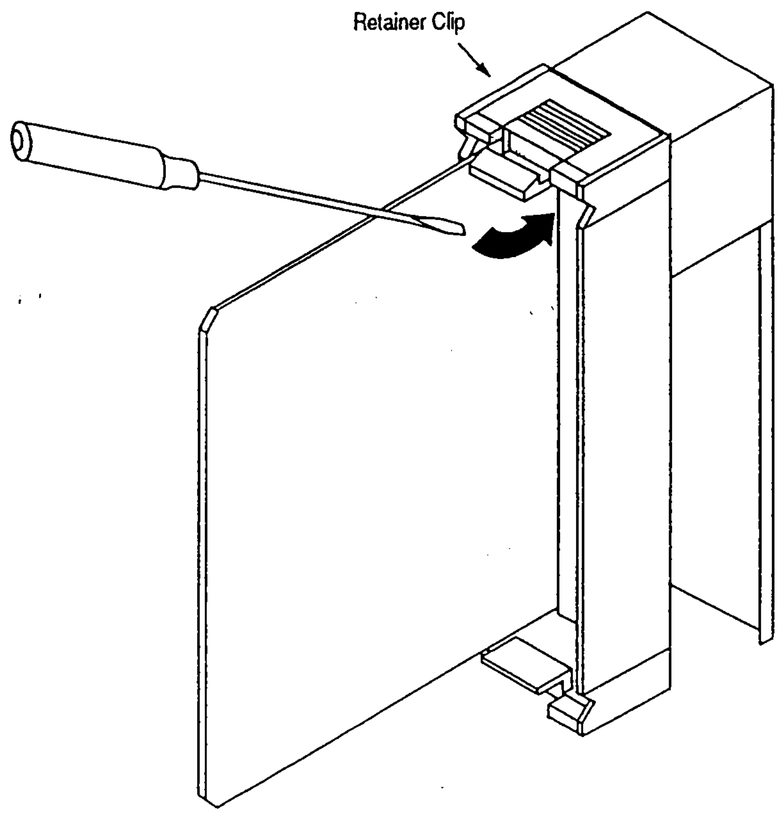
Replacing Retainer Clips on an I/O Module

If it becomes necessary to replace the retainer clip (also called self-locking tab), order Catalog Number 1746-R15 (4 clips per package).



Removing Damaged Retainer Clips

If necessary, pry off the broken retainer clip from the bottom with a screwdriver. Do not twist it off. You can damage the module.



Installing New Retainer Clips

Insert one of the pins of the retainer clip into the hole in the I/O module and then snap the other end in place.

Chapter 8

Troubleshooting

In this chapter, you will learn about:

- calling Allen–Bradley for assistance
- tips for troubleshooting your control system
- troubleshooting your fixed controller
- troubleshooting your input modules
- troubleshooting your output modules

Calling Allen–Bradley for Assistance

If you need to contact Allen–Bradley or your local distributor for assistance, it is helpful to obtain the following (prior to calling):

- processor type, series letter, and firmware (FRN) number (see label on side of processor module)
- processor LED status
- processor error codes (found in S:6 of status file)
- hardware types in system (I/O modules, chassis)
- revision of programming device (on the main menu of the Hand–Held Terminal or Advanced Programming Software)

Tips for Troubleshooting Your Control System

When troubleshooting, pay careful attention to these general warnings:

ATTENTION: Have all personnel remain clear of the controller and equipment when power is applied. The problem may be intermittent and sudden unexpected machine motion could result in injury. Have someone ready to operate an emergency–stop switch in case it becomes necessary to shut off power to the controller equipment. Also, see NFPA 70E Part II for additional guidelines for safety related work practices.

Never reach into a machine to actuate a switch since unexpected machine motion can occur and cause injury.

Remove all electrical power at the main power disconnect switches before checking electrical connections or inputs/outputs causing machine motion.

If installation and start–up procedures detailed in chapters 3, 4, and 5 were followed closely, your SLC controller will give you reliable service. If a problem should occur, the first step in the troubleshooting procedure is to identify the problem and its source.

The SLC 500 controller has been designed to simplify troubleshooting procedures. By observing the diagnostic indicators on the front of the processor unit and I/O modules, the majority of faults can be located and corrected. These indicators, along with error codes identified in the programming device user manual and programmer's monitor, help trace the source of the fault to the user's input/output devices, wiring, or the controller.

Removing Power

Before working on a SLC 500 fixed system, always remove the power supply input power at the main power disconnect switch.

The POWER LED on the power supply indicates that DC power is being supplied to the chassis. This LED could be off when incoming power is present when the:

- fuse is blown
- voltage drops below the normal operating range. Refer to chapter 1 for more information.
- power supply is defective

Replacing Fuses

When replacing a fuse, be sure to remove all power from the system.

Program Alteration

There are several causes of alteration to the user program, including extreme environmental conditions, Electromagnetic Interference (EMI), improper grounding, improper wiring connections, and unauthorized tampering. If you suspect the memory has been altered, check the program against a previously saved program on an EEPROM, UVPROM or Flash EPROM module.

Troubleshooting Your Fixed Controller

To receive the maximum benefit of this troubleshooting section, we recommend you follow these steps:

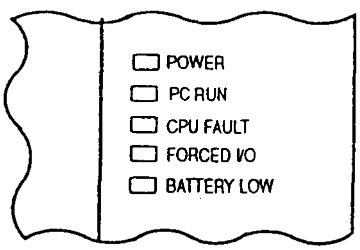
1. Match your processor LEDs with the status LEDs located in the first column in the tables on the following pages.
2. Once the status LEDs are matched to the appropriate table, simply move across the table identifying error description and probable causes.
3. Follow the recommended action steps for each probable cause until the cause is identified.
4. If recommended actions do not identify the cause, contact your local Allen–Bradley sales office or distributor.

Identifying Fixed Controller Errors

Refer to the following key to determine the status of the LED indicators:

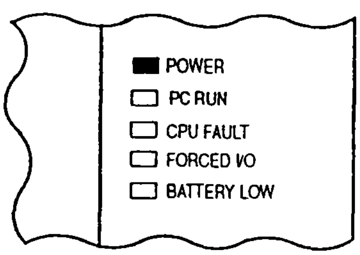
- Indicates the LED is OFF.
- Indicates the LED is ON.
- Indicates the LED is FLASHING.

If the LEDs indicate:



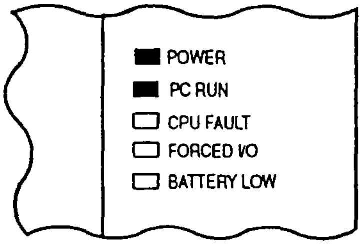
The Fol'owing Error Exists	Probable Cause	Recommended Action
Inadequate System Power	No Line Power	Verify proper line voltage and connections on the power terminals.
	Power Supply Fuse Blown	1. Check the incoming power fuse, check for proper incoming power connections. Replace fuse. 2. If fuse blows again, replace the fixed controller.
	Power Supply Overloaded	This problem can occur intermittently if power supply is lightly overloaded when output loading and temperature varies. If you are using a 2–slot chassis, verify the compatibility of the modules to prevent overloading the backplane power.

If the LEDs indicate:



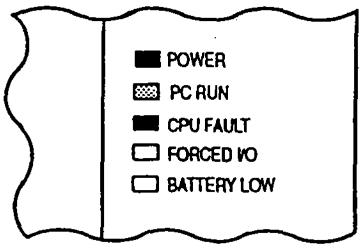
The Following Error Exists	Probable Cause	Recommended Action
Processor Not in Run Mode	Either Improper Mode Selected or User Program Logic Error	1. Verify selected processor mode. 2. If in program/test modes, attempt RUN mode entry. 3. Check user program logic for suspend instructions if in suspend mode. Refer to either the *Hand–Held Terminal User Manual,* Catalog Number 1747–NP002, or the *Advanced Programming Software User Manual,* Catalog Number 1747–NM002.
	Line Power Out of Operating Range	1. Check incoming power connections. 2. Monitor for proper line voltage at the incoming power connections.

If the LEDs indicate:



The Following Error Exists	Probable Cause	Recommended Action
System Inoperable, No Major CPU Faults Detected	User Program Logic Error	Monitor logic in Run mode and verify desired I/O status. Refer to either the *Hand-Held Terminal User Manual*, Catalog Number 1747–NP002, or the *Advanced Programming Software User Manual*, Catalog Number 1747–NM002.
	Defective I/O Devices or I/O Wiring	Test inputs and outputs according to I/O troubleshooting procedures starting on page 8–8.

If the LEDs indicate:



The Following Error Exists	Probable Cause	Recommended Action
CPU Fault	CPU Memory Error	Cycle power.
	Faulty Memory Module	1. Remove power and then remove the memory module from the controller. 2. Re–energize the controller. If steady CPU FAULT LED changes to flashing, replace the existing memory module with a replacement module. Refer to chapter 4 for removing and installing memory modules.
	Processor Firmware Installed Incorrectly	If upgrading the processor to a different firmware level, verify that the firmware chip orientation matches the upgrade kit directions.

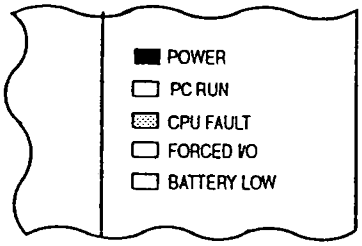
Refer to the following key to determine the status of the LED indicators:

☐ Indicates the LED is OFF.

■ Indicates the LED is ON.

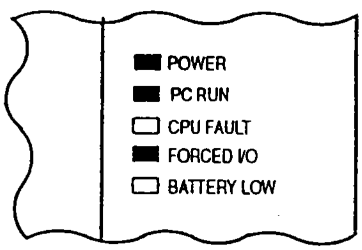
▒ Indicates the LED is FLASHING.

If the LEDs indicate:



The Following Error Exists	Probable Cause	Recommended Action
CPU Major Fault	Initial CPU Factory Power–up Condition	1. Refer to chapter 6 and follow the start–up procedures. 2. Clear processor memory to get rid of the flashing CPU FAULT LED.
	Hardware/Software Major Fault Detected Erratic repetitive power cycling can cause a processor major hardware fault.	1. Monitor Status File Word S:6 for major error code. 2. Refer to either the *Hand–Held Terminal User Manual,* Catalog Number 1747–NP002, or the *Advanced Programming Software User Manual,* Catalog Number 1747–NM002, for error codes and additional troubleshooting information. 3. Remove hardware/software condition causing fault. 4. Clear Status File S:1/13 major error bit, if set. 5. Clear Status File S:5 minor error bits, if set. 6. Clear Status File S:6 major error code (optional). 7. Attempt a processor Run mode entry. If unsuccessful, repeat recommended action steps above.

If the LEDs indicate:

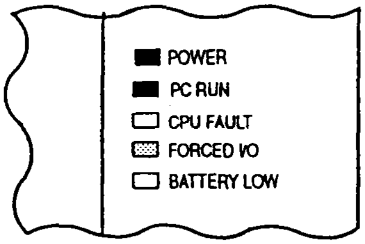


The Following Error Exists	Probable Cause	Recommended Action
System does not operate per ladder logic.	User Forced I/O Disabling Operation	1. Monitor program file online and identify forced I/O. 2. Disable appropriate forces and test system conditions again. Refer to either the *Hand–Held Terminal User Manual,* Catalog Number 1747–NP002, or the *Advanced Programming Software User Manual,* Catalog Number 1747–NM002.

Refer to the following key to determine the status of the LED indicators:

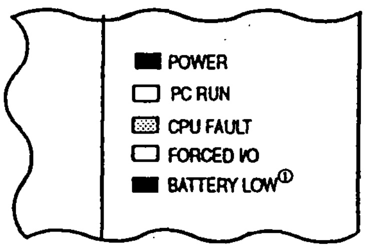
☐ Indicates the LED is OFF.
■ Indicates the LED is ON.
▒ Indicates the LED is FLASHING.

If the LEDs indicate:



The Following Error Exists	Probable Cause	Recommended Action
System does not operate per programmed forces.	User Programmed Forces are Not Enabled	1. Monitor program file online and identify programmed forces. 2. Enable appropriate forces and test system conditions again. Once forces are enabled, the FORCED I/O LED goes on steady. Refer to either the *Hand–Held Terminal User Manual,* Catalog Number 1747–NP002, or the *Advanced Programming Software User Manual,* Catalog Number 1747–NM002.

If the LEDs indicate:



The Following Error Exists	Probable Cause	Recommended Action
CPU Major Error with Low or No Battery Back–up	Loss of RAM during Power Down Period	1. Verify battery is connected. See page 7–4. 2. Replace the battery. See page 7–4. 3. Refer to processor major fault recommended action steps. Refer to either the *Hand–Held Terminal User Manual,* Catalog Number 1747–NP002, or the *Advanced Programming Software User Manual,* Catalog Number 1747–NM002.

Refer to the following key to determine the status of the LED indicators:

Indicates the LED is OFF.

Indicates the LED is ON.

Indicates the LED is FLASHING.

① *Regardless of any other LED status indicator conditions, always replace the battery when the BATTERY LOW LED is on if you want RAM battery backup. If you want to back up RAM with a capacitor, add or replace the BATTERY LOW LED jumper.*

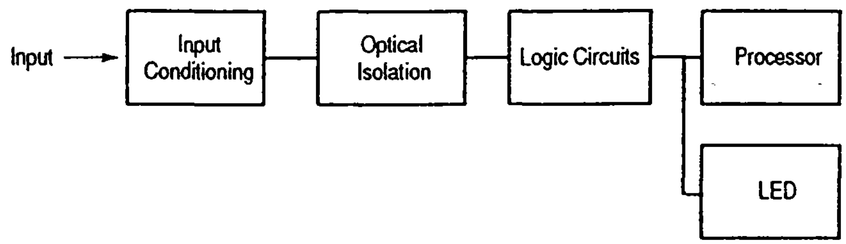
Troubleshooting Your Input Modules

The following will assist you in troubleshooting your input modules.

Input Circuit Operation

An input circuit responds to an input signal in the following manner:

1. An input filter removes false signals due to contact bounce or electrical interference.
2. Optical isolation protects the backplane circuits by isolating logic circuits from input signals.
3. Logic circuits process the signal.
4. An input LED turns on or off indicating the status of the corresponding input device.



5. The processor receives the input status for use in processing the program logic.

Corrective Action

If your Input Circuit LED is	And Your Input Device is	And	Probable Cause	Recommended Action
On	On/Closed/Activated	Your input device will not turn off.	Device is shorted or damaged.	Verify device operation. Replace device.
		Your program operates as though it is off.	Input is forced off in program.	Check the FORCED I/O or FORCE LED on processor and remove forces.
			Input circuit is damaged.	Try other input circuit. Replace module.
	Off/Open/Deactivated	Your program operates as though it is on and/or the input circuit will not turn off.	Input device Off–state leakage current exceeds input circuit specification.	Check device and input circuit specifications. Use load resistor to bleed–off current.
			Input device is shorted or damaged.	Verify device operation. Replace device.
			Input circuit is miswired or damaged.	Verify proper wiring. Try other input circuit. Replace module.
Off	On/Closed/Activated	Your program operates as though it is off and/or the input circuit will not turn on.	Input circuit is incompatible.	Check specification and sink/source compatibility (if DC input).
			Low voltage across the input.	Check the voltage across input circuit and check source voltage.
			Incorrect wiring or an open circuit.	Check wiring and COMmon connections.
			Input signal turn on time too fast for input circuit.	Check timing specifications.
			Input circuit is damaged.	Verify proper wiring. Try other input circuit. Replace module.
	Off/Open/Deactivated	Your input device will not turn on.	Input device is opened or damaged.	Verify operation. Replace device.
		Your program operates as though it is on.	Input is forced on in program.	Check processor FORCED I/O or FORCE LED and remove forces. Verify proper wiring. Try other input circuit.
			Input circuit is damaged.	Verify proper wiring. Try other input circuit. Replace module.

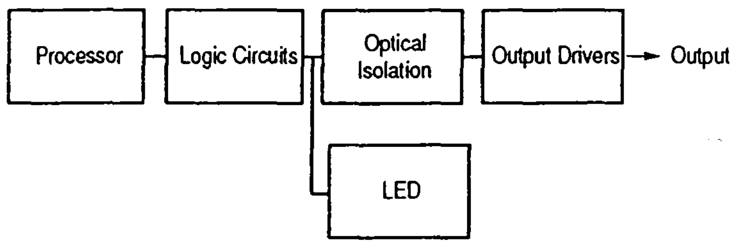
Troubleshooting Your Output Modules

The following will assist you in troubleshooting your output modules.

Output Circuit Operation

An output circuit controls the output signal in the following manner:

1. The processor determines the output status.
2. Logic circuits maintain the output status.
3. An output LED indicates the status of the output signal.
4. Optical isolation separates logic and backplane circuits from field signals.
5. The output driver turns the corresponding output on or off.



Corrective Action

If your Output Circuit LED is	And Your Output Device is	And	Probable Cause	Recommended Action
On	On/Energized	Your program indicates that the output circuit is off or the output circuit will not turn off.	Programming problem.	Check for duplicate outputs and addresses using the search function. If using subroutines, outputs are left in their last state when not executing subroutines. Use the force function to force output off. If this does not force the output off, output circuit is damaged. If the output does force off, then check again for logic/programming problem.
			Output is forced on in program.	Check processor FORCED I/O or FORCE LED and remove forces.
			Output circuit is damaged.	Use the force function to force the output off. If this forces the output off, then there is a logic/programming problem. If this does not force the output off, the output circuit is damaged. Try other output circuit. Replace module.
	Off/De–energized	Your output device will not turn on and the program indicates that it is on.	Low or no voltage across the load.	Measure the source voltage and check specifications.
			Incorrect wiring or open circuit.	Check wiring and COMmon connections.
			Output device is incompatible.	Check specifications and sink/source compatibility (if DC output).
			Output circuit is damaged.	Check wiring. Try other output circuit. Replace module.
Off	On/Energized	Your output device will not turn off and the program indicates that it is off.	Output device is incompatible.	Check specifications.
			Output circuit Off–state leakage current may exceed output device specification.	Check specifications. Use load resistor to bleed off leakage current. See output specifications.
			Incorrect wiring.	Check wiring. Disconnect from SLC and verify device operation.
			Output device is shorted or damaged.	Verify device operation. Replace device.
			Output circuit is damaged.	Check wiring. Try other output circuit. Replace module.
	Off/De–energized	Your program indicates that the output circuit is on or the output circuit will not turn on.	Programming problem.	Check for duplicate outputs and addresses using search function. If using subroutines, outputs are left in their last state when not executing subroutines. Use the force function to force output on. If this does not force the output on, output circuit is damaged. If the output does force on, then check again for logic/programming problem.
			Output is forced off in program.	Check processor FORCED I/O or FORCE LED and remove forces.
			Output circuit is damaged.	Use the force function to force the output on. If this forces the output on, then there is a logic/programming problem. If this does not force the output on, the output circuit is damaged. Try other output circuit. Replace module.

Replacement Parts

This chapter provides a list of replacement parts and a list of replacement terminal blocks for your SLC 500 controller.

Replacement Parts

This table provides a list of replacement parts and their catalog numbers.

Description	Catalog Number
Pre–wired Interface Cable — Available in 1.0m, 2.5m, and 5.0m lengths.	1492–CABLE[①]H
Replacement Fuses — Five fuses per package. Orders must be for five fuses or multiples of five.	
Replacement fuse for Fixed I/O AC units, MDL 1.25 Ampere	1746–F4
Replacement fuse for Fixed I/O DC units, MDL 1.6 Ampere	1746–F5
Modular Card Slot Fillers — Two fillers per package. Orders must be for two fillers or multiples of two.	1746–N2
Connector — Mating Connector for 32 Point user–made cable	1746–N3
Kit consisting of four replacement terminal covers and labels for 4, 8, 16 I/O modules	1746–R9
Replacement Cover for Specialty I/O Two covers per package. Orders must be for two covers or multiples of two.	1746–R13
Replacement Retainer Clips for Modules Four clips per package. Orders must be for four clips or multiples of four.	1746–R15
Lithium Battery Assembly This is an optional part used for the SLC 500 Fixed and Modular Hardware Style processors and the Hand–Held Terminal. Refer to product documentation for proper storage and handling instructions. For disposal information, consult your nearest Allen–Bradley Sales Office.	1747–BA
Processor to Peripheral Programming/Communication Cable	1747–C10
Processor to Isolated Link Coupler Cable	1747–C11
Specialty Module to Isolated Link Coupler Cable	1747–C13
EEPROM with 1K User Instructions	1747–M1
UVPROM with 1K User Instructions	1747–M3
Adapter Sockets — Orders must be for five sockets or multiples of five.	1747–M5
Replacement Parts Kit for 20 I/O Fixed Hardware Style Processor Two Output Terminal Covers Two Input Terminal Covers Two Prom/Battery Covers One HHT/Comm Connector Cover	1747–R5
Replacement Parts Kit for 30 and 40 I/O Fixed Hardware Style Processors Two Output Terminal Covers Two Input Terminal Covers Two Prom/Battery Covers One HHT/Comm Connector Cover	1747–R7
Replacement Terminal Covers for 4, 8, & 16 I/O Modules This kit contains four blank covers and appropriate labels for replacement of any required I/O module cover.	1747–R9
HHT Keypad Replacement Overlay for English Memory Pak Firmware Releases 1.02, 1.07 and 1.10	1747–R20
HHT Keypad Replacement Overlay for French Memory Pak Firmware Releases 1.10	1747–R20F
HHT Keypad Replacement Overlay for German Memory Pak Firmware Releases 1.10	1747–R20G
HHT Keypad Replacement Overlay for Italian Memory Pak Firmware Releases 1.10	1747–R20I
HHT Keypad Replacement Overlay for English Memory Pak Firmware Releases 2.00 and Later	1747–R21
HHT Keypad Replacement Overlay for French Memory Pak Firmware Releases 2.00 and Later	1747–R21F

① *Insert the cable length code into the catalog number. Cable length codes are as follows: 10=1.0m, 25=2.5m, and 50=5.0m. For example, 1492–CABLE25H is a 2.5m cable.*

Replacement Terminal Blocks

This table provides a list of replacement terminal blocks and their catalog numbers.

Description	Catalog Number
Replacement Terminal Block (Red) — Used with AC I/O modules, Catalog Numbers 1746–IA16, OA16, IM16	1746–RT25R
Replacement Terminal Block (Blue) — Used with DC I/O modules, Catalog Numbers 1746–IB16, IV16, OB16, OV16, IN16, IG16, OG16	1746–RT25B
Replacement Terminal Block (Orange) — Used with relay output modules, Catalog Numbers 1746–OW16, OX8	1746–RT25C
Replacement Terminal Block (Green) — Used with Specialty I/O modules, Catalog Numbers 1746–HSCE, IO12	1746–RT25G
Replacement Terminal Block — 2 position terminal block used with analog output modules, Catalog Numbers 1746–NO4I, NO4V	1746–RT26
Replacement Terminal Block — 8 position terminal block used with analog output modules, Catalog Numbers 1746–NO4I, NO4V	1746–RT27
Replacement Terminal Block — Used with analog input modules, Catalog Numbers 1746–NI4, NIO4I, NIO4V	1746–RT28
Replacement Terminal Block — Used with RIO Communication Modules, Catalog Numbers 1747–SN, DSN, DCM	1746–RT29
Replacement Terminal Block — Used with DH–485 Link Coupler, Catalog Number 1747–AIC	1746–RT30

Setting Up the DH–485 Network

The information in this appendix will help you plan, install, and operate the SLC 500 in a DH–485 network. This chapter also contains information that describes the DH–485 network functions, network architecture, and performance characteristics. It also covers:

- DH–485 network description
- DH–485 network protocol
- DH–485 token rotation
- DH–485 network initialization
- devices that use the DH–485 network
- 1747–AIC isolated link coupler for DH–485
- example system configuration
- important planning considerations
- DH–485 network installation

DH–485 Network Description

We have designed the DH–485 network to pass information between devices on the plant floor. The network monitors process parameters, device parameters, device status, process status and application programs to support data acquisition, data monitoring, program upload/download and supervisory control.

The DH–485 network offers:

- interconnection of 32 devices
- multi–master capability
- token passing access control
- the ability to add or remove nodes without disrupting the network
- maximum network length of 1219 m (4000 ft)

DH–485 Network Protocol

The following section describes the protocol used to control message transfers on the DH–485 network. The protocol supports two classes of devices: initiators and responders. All initiators on the network get a chance to initiate message transfers. To determine which initiator has the right to transmit, a token passing algorithm is used.

DH–485 Token Rotation

A node holding the token can send any valid packet onto the network. Each node is allowed only one transmission (plus two retries) each time it receives the token. After a node sends one message packet, it attempts to give the token to its successor by sending a "token pass" packet to its successor.

If no network activity occurs, the initiator sends the token pass packet again. After two retries (a total of three tries) the initiator will attempt to find a new successor.

Important: The maximum address that the initiator will search for before wrapping to zero is the value in the configurable parameter "maximum node address." The default value for this parameter is 31 for all initiators and responders.

The allowable range of the node address of an initiator is 0 to 31. The allowable address range for all responders is 1 to 31. There must be at least one initiator on the network.

DH–485 Network Initialization

Network initialization begins when a period of inactivity exceeding the time of a link dead timeout is detected by an initiator on the network. When the time for a link dead timeout is exceeded, usually the initiator with the lowest address claims the token. When an initiator has the token it will begin to build the network. The network requires at least one initiator to initialize it.

Building a network begins when the initiator that claimed the token tries to pass the token to the successor node. If the attempt to pass the token fails, or if the initiator has no established successor (for example, when it powers up), it begins a linear search for a successor starting with the node above it in the addressing.

When the initiator finds another active initiator, it passes the token to that node, which repeats the process until the token is passed all the way around the network to the first node. At this point, the network is in a state of normal operation.

Devices that Use the DH–485 Network

Presently, the following SLC 500 devices support the DH–485 network:

- SLC 500 Fixed I/O Controller (responder)
- SLC 5/01 Modular I/O Controller (responder)
- SLC 5/02 Modular I/O Controller (initiator/responder)
- SLC 5/03 Modular I/O Controller (initiator/responder)
- Personal computer running SLC 500 Advanced Programming Software (initiator)
- Hand–Held Terminal (initiator)
- DTAM (initiator/responder)

Other devices that use the DH–485 network include those in the table below.

Catalog Number	Description	Installation Requirement	Function	Publication
1746–BAS	BASIC Module	SLC Chassis	Provides an interface for SLC 500 devices to foreign devices. Program in BASIC to interface the 3 channels (2 RS–232 and 1 DH485) to printers, modems, or the DH–485 network for data collection.	1746–ND005 1746–NM002 1746–NM001
1747–KE	DH–485/DF1 Interface Module	SLC Chassis	Provides a non–isolated DH–485 interface for SLC 500 devices to host computers over RS–232 using full– or half–duplex DF1 protocol. Enables remote programming with APS to an SLC 500 processor or the DH–485 network through modems. Ideal for low cost RTU/SCADA applications.	1747–NU001
1770–KF3	DH–485/DF1 Interface Module	Standalone ("desktop")	Provides an isolated DH–485 interface for SLC 500 devices to host computers over RS–232 using full– or half–duplex DF1 protocol. Enables remote programming with APS to an SLC 500 processor or the DH–485 network through modems.	1770–6.5.18
1784–KR	PC DH–485 Interface Module	IBM XT/AT Computer Bus	Provides an isolated DH–485 port on the back of the computer. When used with APS software, it improves communication speed and eliminates use of the Personal Interface Converter (1747–PIC). The Standard Driver allows you to write "C" programs for data acquisition applications.	1784–2.23 6001–6.5.5
1785–KA5	DH+™/DH485 Gateway	(1771) PLC® Chassis	Provides communication between stations on the PLC–5 (DH+) and SLC 500 (DH–485) networks. Enables communication and data transfer from PLC to SLC 500 on DH–485 network. Also enables APS programming or data acquisition across DH+ to DH–485.	1785–6.5.5 1785–1.21
2760–RB	Flexible Interface Module	(1771) PLC Chassis	Provides an interface for SLC 500 (using protocol cartridge 2760–SFC3) to other A–B PLCs and devices. Three configurable channels are available to interface with Bar Code, Vision, RF, Dataliners, and PLC systems.	2760–ND001

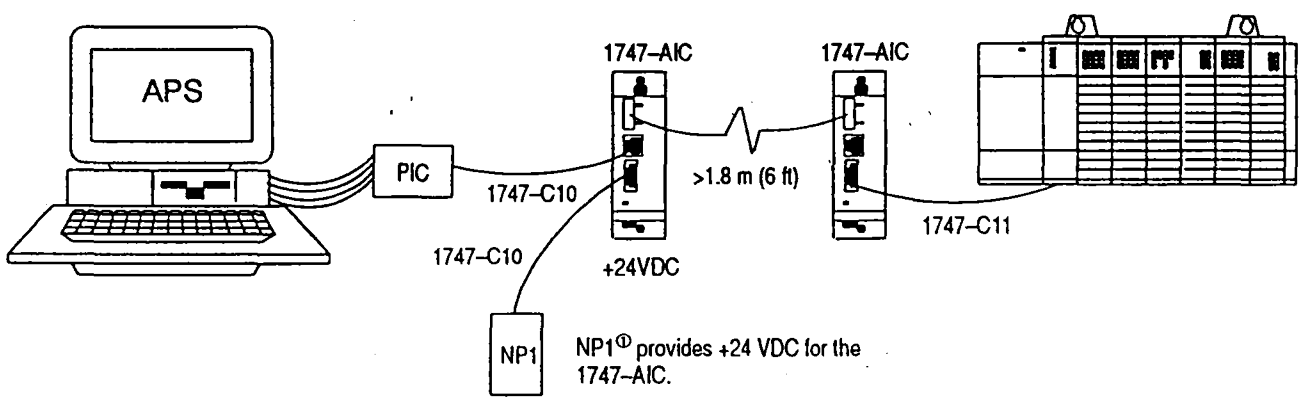
1747–AIC Isolated Link Coupler for DH–485

The isolated link coupler (1747–AIC) is used to connect SLC 500 family devices to the DH–485 network (as shown on page A–5). The coupler provides a 6–position removable terminal block for connection to the DH–485 communication cable.

Network connections for the SLC 500 processor are provided by the Catalog Number 1747–C11, 304.8 mm (12 in.) cable supplied with the link coupler. Network connections for peripheral devices, such as the Personal Interface Converter (1747–PIC), Data Table Access Module (1747–DTAM–E), or Hand–Held Terminal (1747–PT1) are provided by the standard Catalog Number 1747–C10 1.8 m (6 ft) cable supplied with each of those devices.

To protect connected devices, the coupler provides 1500 VDC isolation between the communications cable and the attached SLC 500 controller and peripheral devices (PIC, DTAM, or HHT).

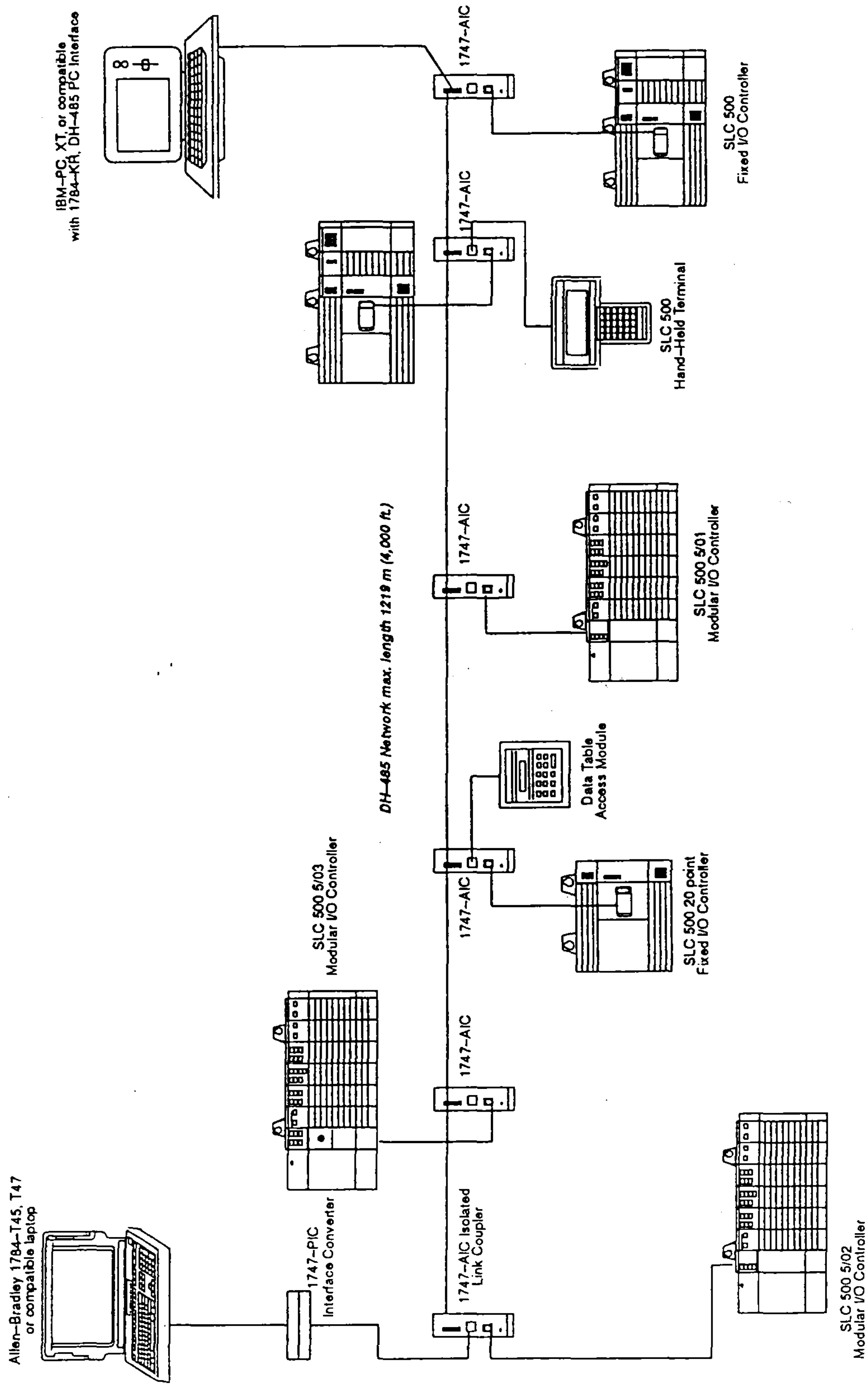
The isolated link coupler can also be used to provide connectivity between a peripheral device (APS and PIC, HHT, or DTAM) for distances greater than 1.8 m (6 ft) up to a maximum of 1219 m (4000 ft). Below is an example of a "remote" connection between a computer running APS and an SLC 500 processor.



[1] *You can also use an NP2 desktop model.*

Example System Configuration

Below is an example of a DH–485 network.



Important Planning Considerations

Carefully plan your network configuration before installing any hardware. Listed below are some of the factors that can affect system performance:

- amount of electrical noise, temperature, and humidity in the network environment
- number of devices on the network
- connection and grounding quality in installation
- amount of communication traffic on the network
- type of process being controlled
- network configuration

The major hardware and software issues you need to resolve before installing a network are discussed in the following sections.

Hardware Considerations

You need to decide the length of the communication cable, where you route it, and how to protect it from the environment where it will be installed.

When the communication cable is installed, you need to know how many devices are to be connected during installation and how many devices will be added in the future. The following sections will help you understand and plan the network.

Number of Devices and Length of Communication Cable

You must install a link coupler (1747–AIC) for each node on the network. If you plan to add nodes later, provide additional link couplers during the initial installation to avoid recabling after the network is in operation.

The maximum length of the communication cable is 1219 m (4000 ft). This is the total cable distance from the first node to the last node on the network.

Planning Cable Routes

Follow these guidelines to help protect the communication cable from electrical interference:

- Keep the communication cable at least five feet from any electric motors, transformers, rectifiers, generators, arc welders, induction furnaces, or sources of microwave radiation.
- If you must run the cable across power feed lines, run the cable at right angles to the lines.
- If you do not run the cable through a contiguous metallic wireway or conduit, keep the communication cable at least 0.15 m (6 in) from ac power lines of less than 20 A, 0.30 m (1 ft) from lines greater than 20 A, but only up to 100 kVA, and 0.60 m (2 ft) from lines of 100 kVA or more.
- If you run the cable through a contiguous metallic wireway or conduit, keep the communication cable at least 0.08 m (3 in) from ac power lines of less than 20 A, 0.15 m (6 in) from lines greater than 20 A, but only up to 100 kVA, and 0.30 m (1 ft) from lines of 100 kVA or more.

Running the communication cable through conduit provides extra protection from physical damage and electrical interference. If you route the cable through conduit, follow these additional recommendations:

- Use ferromagnetic conduit near critical sources of electrical interference. You can use aluminum conduit in non–critical areas.
- Use plastic connectors to couple between aluminum and ferromagnetic conduit. Make an electrical connection around the plastic connector (use pipe clamps and the heavy gauge wire or wire braid) to hold both sections at the same potential.
- Ground the entire length of conduit by attaching it to the building earth ground.
- Do not let the conduit touch the plug on the cable.
- Arrange the cables loosely within the conduit. The conduit should contain only serial communication cables.
- Install the conduit so that it meets all applicable codes and environmental specifications.

For more information on planning cable routes, see *Industrial Automation Wiring and Grounding Guidelines*, publication number 1770–4.1.

Software Considerations

Software considerations include the configuration of the network and the parameters that can be set to the specific requirements of the network. The following are major configuration factors that have a significant effect on network performance:

- number of nodes on the network
- addresses of those nodes
- baud rate
- maximum node address selection
- *5/03 only*: token hold factor

The following sections explain network considerations and describe ways to select parameters for optimum network performance (speed).

Number of Nodes

The number of nodes on the network directly affects the data transfer time between nodes. Unnecessary nodes (such as a second programming terminal that is not being used) slow the data transfer rate. The maximum number of nodes on the network is 32.

Setting Node Addresses

The best network performance occurs when node addresses start at 0 and are assigned in sequential order. SLC 500 processors default to node address 1. The node address is stored in the processor status file (S:15L). Processors cannot be node 0. Also, initiators such as personal computers should be assigned the lowest numbered addresses to minimize the time required to initialize the network.

If some nodes are connected on a temporary basis, do not assign addresses to them. Simply create nodes as needed and delete them when they are no longer required.

Setting Processor Baud Rate

The best network performance occurs at the highest baud rate, which is 19200. All devices must be at the same baud rate. The default baud rate for SLC 500 devices is 19200. The baud rate is stored in the processor status file (S:15H).

Maximum Node Address Setting

The maximum node address parameter should be set as low as possible. This minimizes the amount of time used in soliciting successors when initializing the network. If all nodes are addressed in sequence from 0, and the maximum node address is equal to the address of the highest addressed node, the token rotation will improve by the amount of time required to transmit a solicit successor packet plus the slot timeout value.

Note that this does not allow any node to be added to the network without affecting the response time. On the other hand, since the time required to hold an open station address is greater than the time required to pass a token, it can be useful to leave a temporary device (such as a personal computer) connected if there is only one such device. (A solicit successor packet requires the same transmission time as the token pass, but there is an added slot timeout period.)

See the *Hand–Held Terminal User Manual*, Catalog Number 1747–NP002, or the *Advanced Programming Software User Manual*, Catalog Number 1747–NM002, for the procedures to set node addresses, processor baud rate, and maximum node addresses.

Important: The SLC 500 Series A (only) processors set the maximum node address to 31 when power is cycled increasing initialization and response time of the network.

DH–485 Network Installation

To install a DH–485 network, you will need tools to strip the shielded cable and to attach the cable and terminators to the isolated link coupler. Install the DH–485 network using the following tools (or equivalent):

Description	Part Number	Manufacturer
Shielded Twisted Pair Cable	#9842	Belden
Stripping Tool	45–164	Ideal Industries
1/8 " Slotted Screwdriver	NA	NA

DH–485 Communication Cable and Isolated Link Coupler

The link coupler provides a connection for each node. The isolated link coupler electrically isolates the DH–485 communication interface from the processor and peripheral connections. Electrical–optical isolation is provided to 1500 VDC.

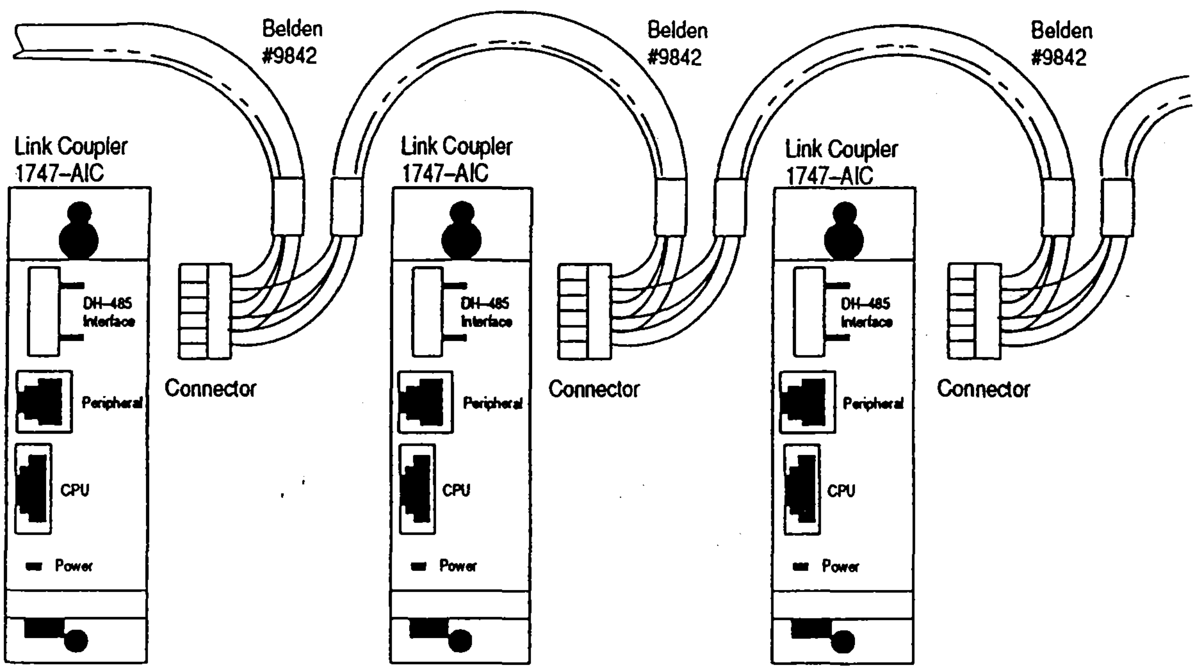
The suggested DH–485 communication cable is Belden #9842 cable. The cable is jacketed and shielded with two twisted wire pairs and a drain wire.

One pair provides a balanced signal line, and one wire of the other pair is used for a common reference line between all nodes on the network. The shield reduces the effect of electrostatic noise from the industrial environment on the network communication.

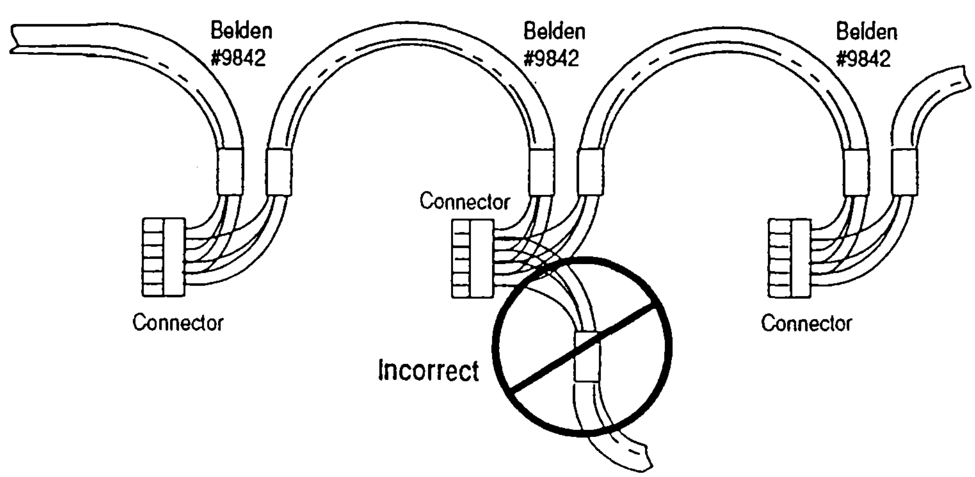
Installing the DH-485 Communication Cable

The communication cable consists of a number of cable segments daisy-chained together. The total length of the cable segments cannot exceed 1219 m (4000 ft).

When cutting cable segments, make them long enough to route them from one link coupler to the next with sufficient slack to prevent strain on the connector. Allow enough extra cable to prevent chafing and kinking in the cable.



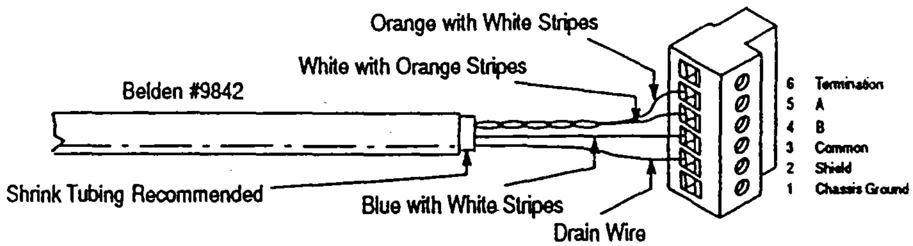
Important: We only recommend a network that is daisy-chained. For example, we do *not* recommend the following:



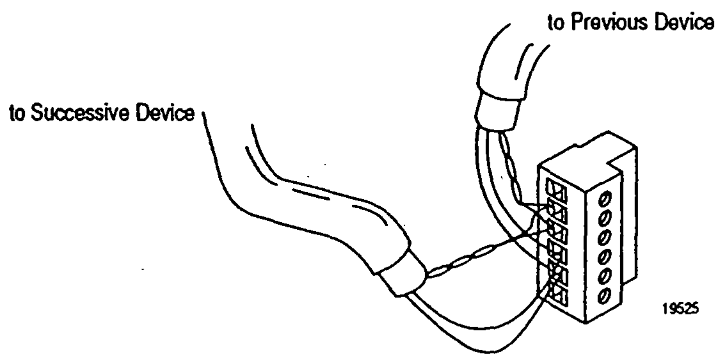
Connecting the Communication Cable to the Isolated Link Coupler

Attach the terminal block of the link coupler to the Belden #9842 cable as shown below. Additional terminal blocks are available for replacement, see chapter 9.

Single Cable Connection



Multiple Cable Connection



The table below shows wire/terminal connections for DH–485 connectors for *old* Belden #9842.

For this Wire/Pair	Connect this Wire	To this Terminal
Shield/Drain	Non–jacketed	Terminal 2 – Shield
Black/White	Black	Cut back – no connection[1]
	White	Terminal 3 – (Common)
Black/Red	Black	Terminal 4 – (Data B)
	Red	Terminal 5 – (Data A)

[1] *To prevent confusion when installing the communication cable, cut back the black wire immediately after the the insulation jacket is removed. This wire is not used by DH–485.*

The table below shows wire/terminal connections for DH–485 connectors for *new* Belden #9842.

For this Wire/Pair	Connect this Wire	To this Terminal
Shield/Drain	Non–jacketed	Terminal 2 – Shield
Blue/White	White with Blue Stripe	Cut back – no connection[1]
	Blue with White Stripe	Terminal 3 – (Common)
White/Orange	White with Orange Stripe	Terminal 4 – (Data B)
	Orange with White Stripe	Terminal 5 – (Data A)

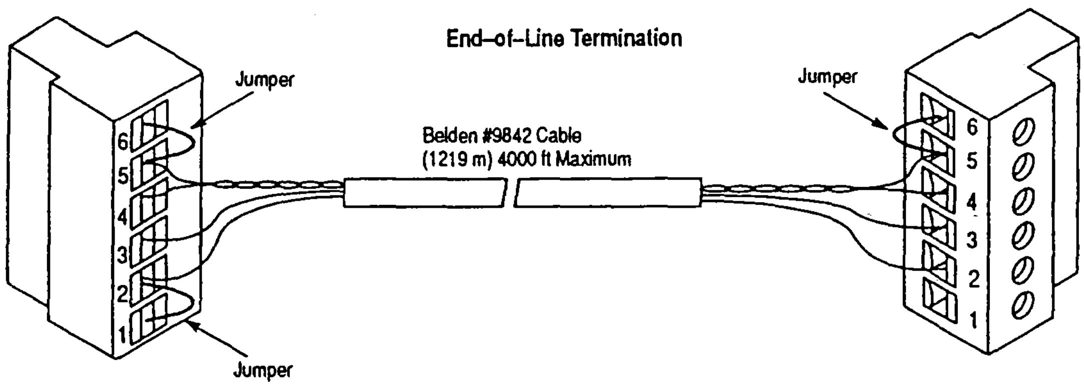
[1] *To prevent confusion when installing the communication cable, cut back the white with blue stripe wire immediately after the the insulation jacket is removed. This wire is not used by DH–485.*

Important: In Series A 1747–AIC, terminal 5 was called DATA B and terminal 4 was called DATA A. In this case, use terminal numbers only and ignore signal names DATA B and DATA A. The internal circuitry of the Series A is the same as Series B.

Grounding and Terminating the DH–485 Network

One (only one) of the link couplers at the end of the link must have Terminals 1 and 2 of the network connector jumpered together. This provides an earth ground connection for the shield of the communication cable.

Link couplers at both ends of the network must have Terminals 5 and 6 of the link connectors jumpered together. This connects the termination impedance (of 120Ω) that is built into each link coupler as required by the DH–485 specification. See the figure below for the proper jumpering.



Powering the Link Coupler

In normal operation with the programmable controller connected to the link coupler, the processor powers both the link coupler and peripheral device (DTAM, PIC, HHT) — if connected — through the C11 cable.

If you do not connect the processor to the link coupler, then use a 24 VDC power supply to power the link coupler and peripheral device. The 1747–AIC requires 85mA at 24 VDC. With a peripheral device connected, the total current required is 190mA at 24 VDC.

If both the processor and external power are connected to the link coupler, only the external source is used.

Important: Always connect the CHS GND (chassis ground) terminal to the nearest earth ground. This connection must be made whether or not an external 24 VDC supply is used.

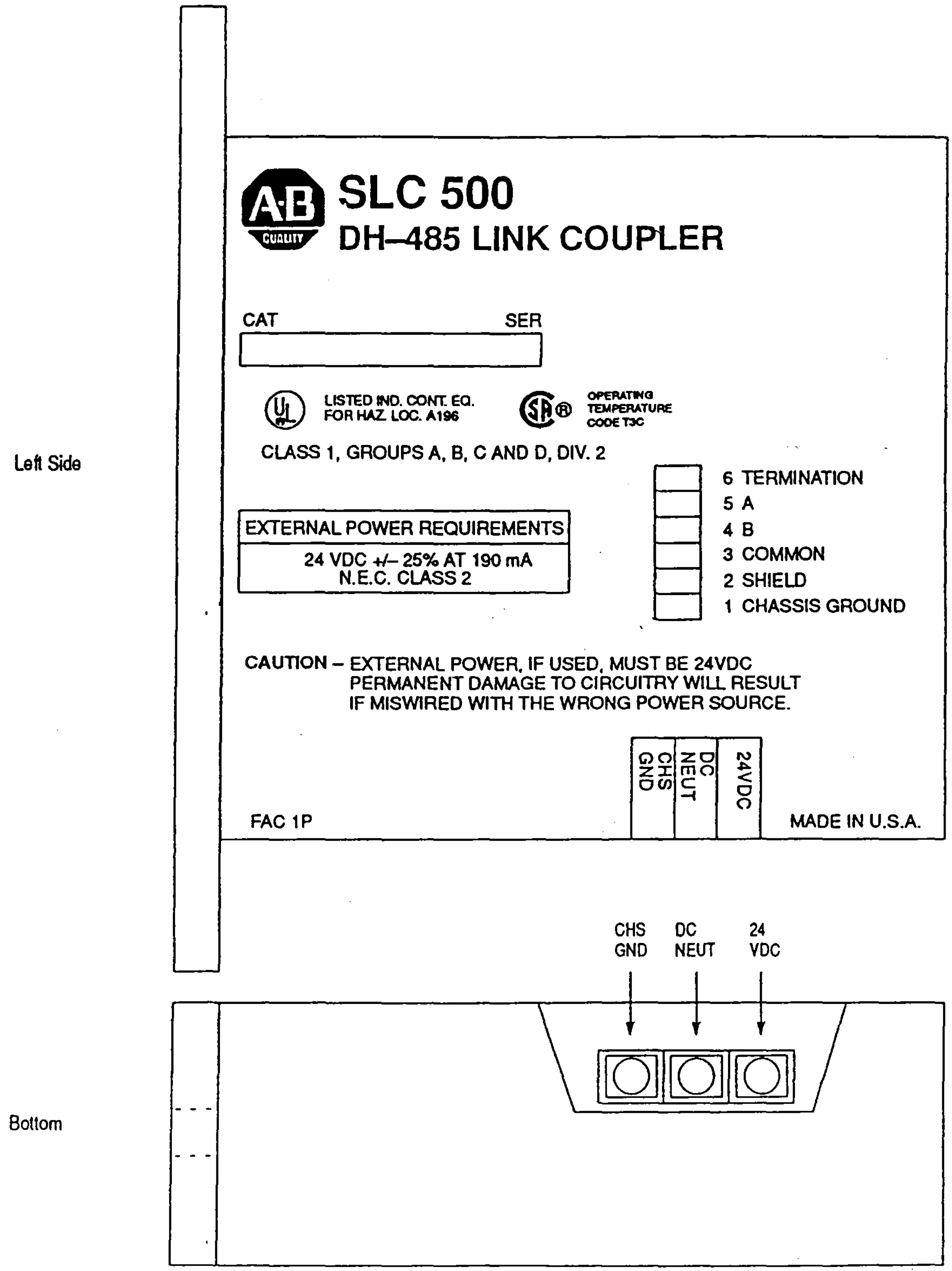
Below are three options for externally powering the 1747–AIC:

- If the link coupler is to be installed in an office environment, you can use the wall mount power supply (1747–NP1) or global desktop power supply (1747–NP2). The link coupler would be powered through either the 1747–C10 cable or by hardwiring from the supply to the screw terminals on the link coupler.
- If you use the AC chassis power supplies (1746–P1 or 1746–P2), you can use the 24 VDC user power supply (200mA maximum) built into the power supply. The link coupler would be powered through a hard–wired connection from the screw terminals on the power supply to the screw terminals on bottom of the link coupler.
- You can use an external DC power supply with the following specifications:
  - operating voltage: 24 VDC $\pm$ 25%
  - output current: 190mA
  - rated NEC

  The link coupler would be powered through a hard–wired connection from the external supply to the screw terminals on the bottom of the link coupler.

ATTENTION: If you use an external power supply, it must be 24 VDC. Permanent damage will result if miswired with the wrong power source.

The figure below shows the external wiring connections and specifications of the link coupler.



You can connect an unpowered link coupler to the DH–485 network without disrupting network activity. In addition, if an SLC 500 controller powers a link coupler that is connected to the DH–485 network, network activity will not be disrupted should the SLC 500 controller be removed from the link coupler.

Installing and Attaching the Link Couplers

1. Take care when installing the link coupler in an enclosure so that the cable connecting the SLC 500 controller to the link coupler does not hit the enclosure door.
2. Carefully plug the terminal block into the DH–485 port on the link coupler you are putting on the network. Allow enough cable slack to prevent stress on the plug.
3. Provide strain relief for the Belden #9842 cable after it is wired to the terminal block. This guards against breakage of the Belden cable wires.

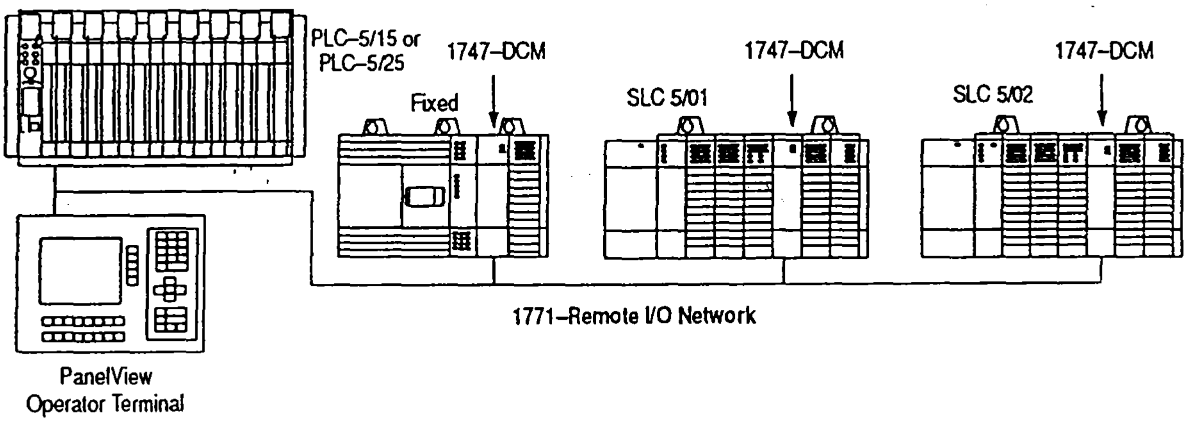
The 1771–Remote I/O Network

This appendix provides a brief introduction about the 1771–Remote I/O Network. For information on the 1771–Remote I/O Network, see the *Direct Communication Module User Manual,* Catalog Number 1747–NM007 and the *Remote I/O Scanner User Manual,* Catalog Number 1747–NM005.

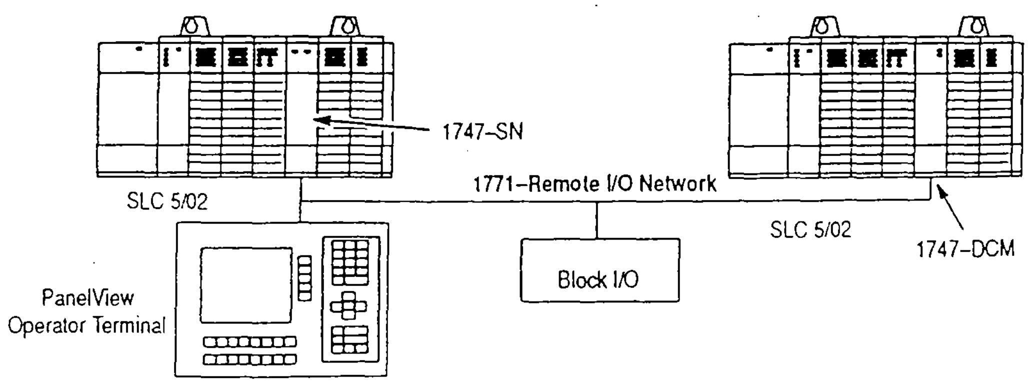
1771–Remote I/O Network

The Allen–Bradley 1771–Remote I/O Network enables chassis of I/O, operator interface terminals, push–button panels, blocks of I/O, message displays, drives and much more to be great distances from the host PLC processor. The SLC 500 controller (fixed, 5/01, 5/02, or 5/03) can interface to this network through the 1747–DCM module for distributed processing. The DCM allows the SLC 500 to look like another device on the network.

Below is an example of the 1771–Remote I/O Network.



With the SLC 5/02 or 5/03 processor, a 1747–SN Remote I/O Scanner can be used as the host of the remote I/O network. With a SLC 5/02 or 5/03 and SN, a PLC is not required on the network.



Appendix C

RS–232 Communication Interface

This appendix provides an overview of the RS–232 communication interface. This appendix also provides information on the following:

- RS–232 and SCADA applications
- RS–232 communication interface overview
- SLC 500 devices that support RS–232 communication
- wiring connectors for RS–232 communication

RS–232 and SCADA Applications

RS–232 is a communication interface included under SCADA (Supervisory Control and Data Acquisition) applications. SCADA is a term that refers to control applications that require communication over long distances. For more information about the use of Allen–Bradley equipment in SCADA applications, refer to the *Allen–Bradley SCADA Applications Guide,*. Publication Number ICCG–11.6.

RS–232 Communication Interface Overview

RS–232 is an Electronics Industries Association (EIA) standard that specifie the electrical, mechanical, and functional characteristics for serial binary communication. It provides you with a variety of system configuration possibilities that differ from those offered by DH–485.

One of the biggest benefits of RS–232 communication is that it lets you integrate telephone and radio modems into your control system. The distance over which you are able to communicate with certain system devices is virtually limitless.

The SLC and PLC products detailed in this appendix that communicate over the RS–232 communication interface also use the DF1 serial communication protocol. DF1 protocol delimits messages, controls message flow, detects and signals errors, and retries after errors are detected.

SLC 500 Devices that Support RS–232 Communication

The SLC 500 product line has three other modules, aside from the SLC 5/03 processor, that support the RS–232 communication interface. They are the DH–485 Communication Interface (1770–KF3), the BASIC module (1746–BAS), and the DH–485/RS–232C Interface (1747–KE). All three of these modules can be used with SLC 500 Fixed Controller.

1770–KF3 Module

The 1770–KF3 module links host computers with the Allen–Bradley DH–485 Data Highway. The host computer communicates with the 1770–KF3 over an RS232 link using DF1 protocol. Through the 1770–KF3, the host computer can communicate with the nodes on the DH–485 network.

For more information on the 1770–KF3 module, see the *DH–485 Communication Interface User Manual*, Catalog Number 1770–6.5.18.

1747–KE Module

The 1747–KE is a communication interface module that acts as a bridge between DH–485 networks and devices requiring DF1 protocol. You can configure the DF1 port on the 1747–KE for RS–232/423, RS–422, or RS–485 devices. Residing in an SLC 500 chassis, the 1747–KE is ideally used as an interface module, linking remote DH–485 networks via a modem to a central host.

For more information on the 1747–KE module, see the *DH–485/RS–232 Interface Module User Manual*, Catalog Number 1747–NU001.

1746–BAS Module

The 1746–BAS module, which is programmed using the BASIC language, has two configurable serial ports for interfacing to computers, modems, printers, and other RS–232 compatible devices. You can also use it for off–loading complex math routines from an SLC 500 processor; this conserves valuable ladder logic memory.

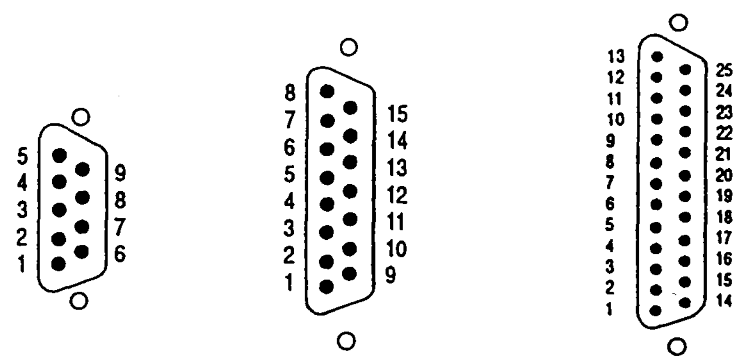
For more information on the 1746–BAS module, see the *SLC 500 BASIC Module Design and Integration Manual*, Catalog Number 1746–ND005.

Wiring Connectors for RS–232 Communication

To connect Allen–Bradley devices with other devices over RS–232, you must wire the cable connectors so that communication can occur through the cabling, which provide the interface between devices.

Types of RS–232 Connectors

The figure below shows male connectors, and their pinout locations, for Allen–Bradley modules.



9–point Connector (Male) 15–point Connector (Male) 25–point Connector (Male)

DTE Pinout

Channel 0, which the 5/03 processor has, is configured as DTE. The pinouts are the same as the 9–pin AT port.

DTE 9 pinout		Signal is	Equivalent DTE 15 pinout	Equivalent DTE 25 pinout
1 –DCD	Data Carrier Detect	Input	8	8
2 –RXD	Received Data	Input	3	3
3 –TXD	Transmit'ed Data	Output	2	2
4 –DTR	Data Terminal Ready	Output	11	20
5 –COM	Common Return (Signal Ground)	Shared	7	7
6 –DSR	Data Set Ready	Input	6	6
7 –RTS	Request to Send	Output	4	4
8 –CTS	Clear to Send	Input	5	5
9 –NC	No Connection	Input		22 RI Ring Indicator

DCE Pinout

Devices such as a modem are DCE. The pinouts on these terminals are wired to interface with DTE.

DCE 9 pinout		Signal is	Equivalent DCE 25 pinout
1 –DCD	Data Carrier Detect	Output	8
2 –RXD	Received Data	Output	3
3 –TXD	Transmitted Data	Input	2
4 –DTR	Data Terminal Ready	Input	20
5 –COM	Common Return (Signal Ground)	Shared	7
6 –DSR	Data Set Ready	Output	6
7 –RTS	Request to Send	Input	4
8 –CTS	Clear to Send	Output	5
9 –RI	Ring Indicator	Output	22

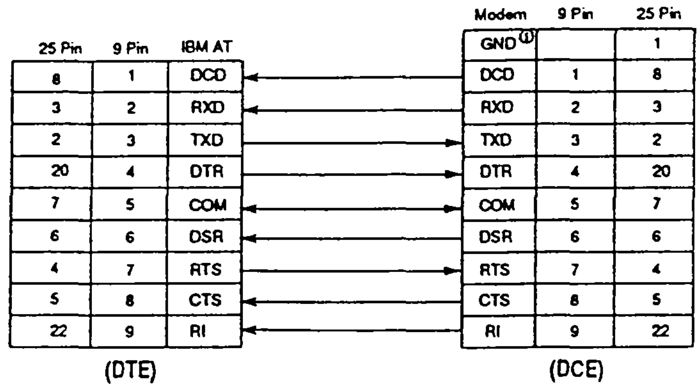
Important: DCE signal names are viewed from a DTE perspective. For example, TXD is a DTE output and also a DCE input.

Pin Assignments for Wiring Connectors

Use the following pin assignments to wire the connectors of Allen–Bradley control devices with modems and peripheral devices that support RS–232 communication. See the table below to find the wiring diagram that you need.

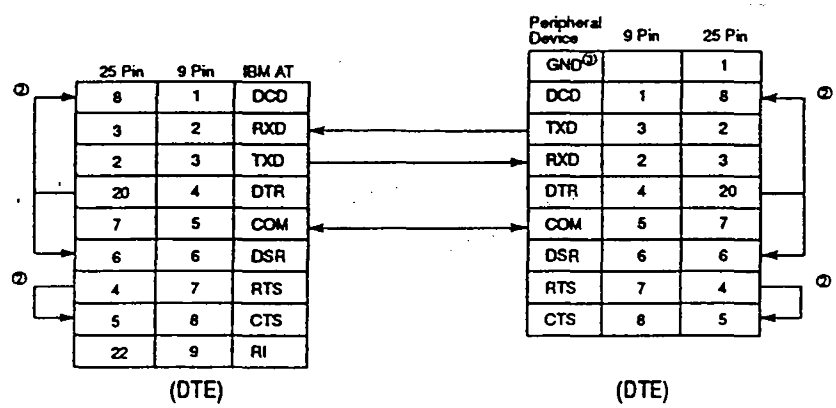
To Connect this Device	To this Device	Remarks	See this Page
IBM AT	Modem	Hardware Handshaking Enabled	C–6
	Peripheral DTE	Hardware Handshaking Disabled	C–6
1747–KE	Modem	Hardware Handshaking Enabled	C–7
	Peripheral DTE	Hardware Handshaking Disabled	C–7
1746–BAS	Modem	Hardware Handshaking Enabled	C–8
	Peripheral DTE	Hardware Handshaking Disabled	C–8
1770–KF3	Modem	Hardware Handshaking Enabled	C–8
2760–RB	Modem	Hardware Handshaking Enabled	C–9
	Peripheral DTE	Hardware Handshaking Disabled	C–9
1771–KGM (PLC–2)	Modem	Hardware Handshaking Enabled	C–10
	Peripheral DTE	Hardware Handshaking Disabled	C–10
1775–KA (PLC–3)	Modem	Hardware Handshaking Enabled	C–11
	Peripheral DTE	Hardware Handshaking Disabled	C–11
PLC–5 (channel 0)	Modem	Hardware Handshaking Enabled	C–12
	Peripheral DTE	Hardware Handshaking Disabled	C–12
5130–RM (PLC–5/250)	Modem	Hardware Handshaking Enabled	C–13
	Peripheral DTE	Hardware Handshaking Disabled	C–13

IBM AT to a Modem (Hardware Handshaking Enabled)



① *Connect to the shield of the cable.*

IBM AT to a 5/03 Processor, 1770–KF3, 1775–KA, 1773–KA, 5130–RM, or PLC–5 (Hardware Handshaking Disabled) ①

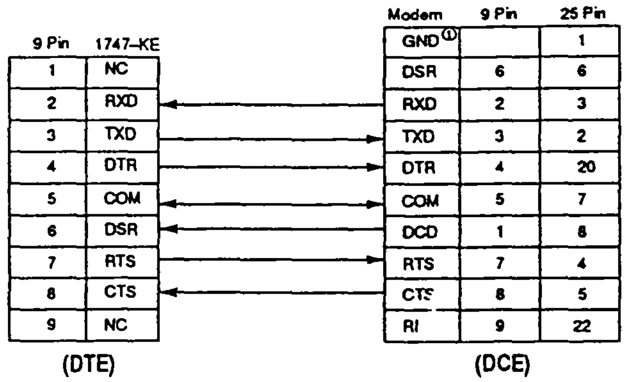


① *You can also use cable 1747–CP3.*

② *Jumpers are only needed if you cannot disable the hardware handshaking on the port.*

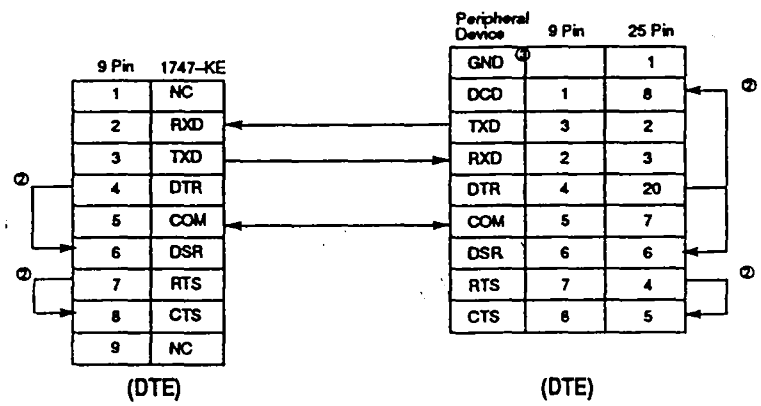
③ *Connect to the shield of the cable.*

1747–KE to a Modem (Hardware Handshaking Enabled)



① Connect to the shield of the cable.

1747–KE to a 5/03 Processor, IBM AT, 1770–KF3, 1775–KA, 1773–KA, 5130–RM, or PLC–5 (Hardware Handshaking Disabled) ①

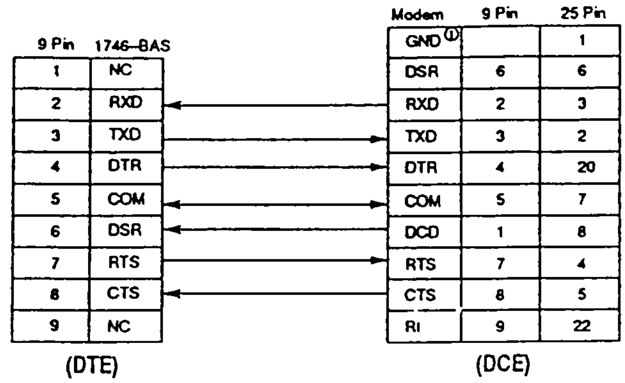


① You can also use cable 1747–CP3.

② Jumpers are only needed if you cannot disable the hardware handshaking on the port.

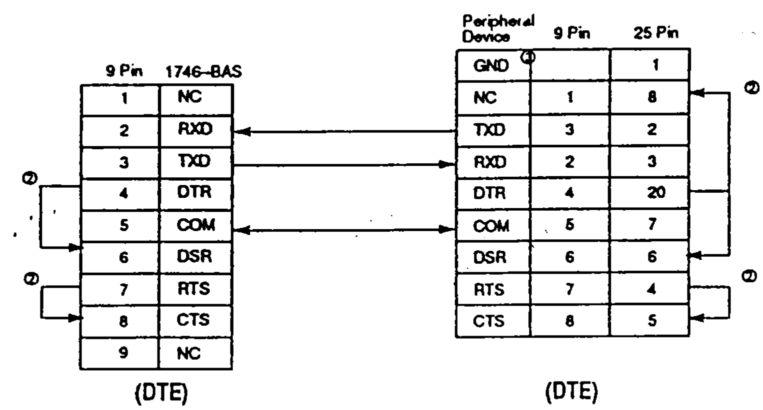
③ Connect to the shield of the cable.

1746–BAS to a Modem (Hardware Handshaking Enabled)



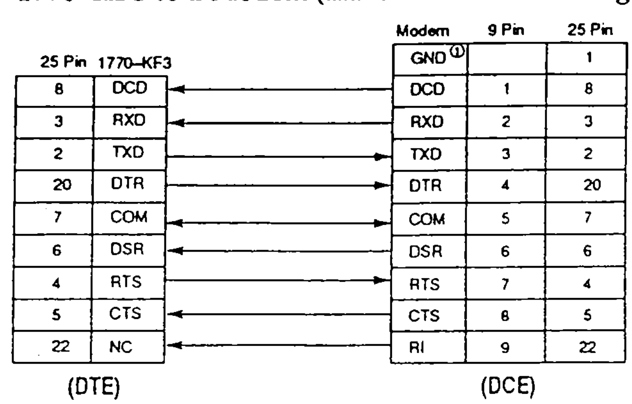
① *Connect to the shield of the cable.*

1746–BAS to a 5/03 Processor, IBM AT, 1770–KF3, 1775–KA, 1773–KA, 5130–RM, or PLC–5 (Hardware Handshaking Disabled)①



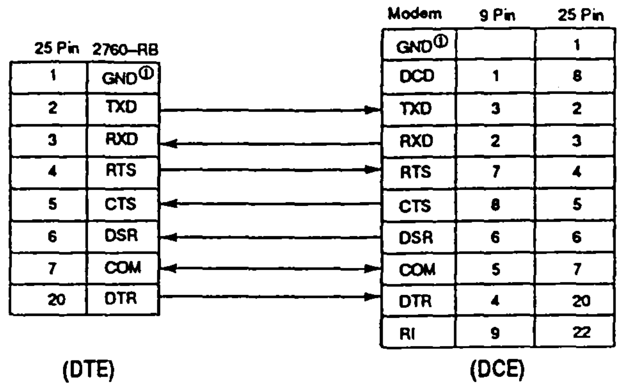
① *You can also use cable 1747–CP3.*
② *Jumpers are only needed if you cannot disable the hardware handshaking on the port.*
③ *Connect to the shield of the cable.*

1770–KF3 to a Modem (Hardware Handshaking Enabled)



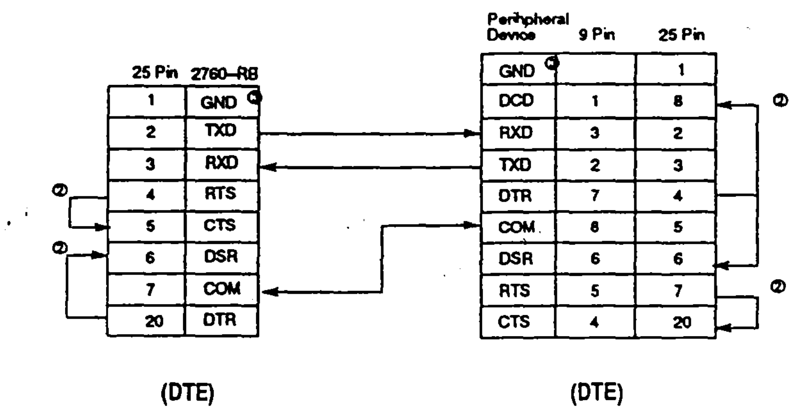
① *Connect to the shield of the cable.*

2760–RB to a Modem (Hardware Handshaking Enabled)



① Connect the shield of the cable to the GND pin on one end only. Leave the other end open.

2760–RB to a 5/03 Processor, IBM AT, 1770–KF3, 1775–KA, 1773–KA, 5130–RM, or PLC–5 (Hardware Handshaking Disabled) ①

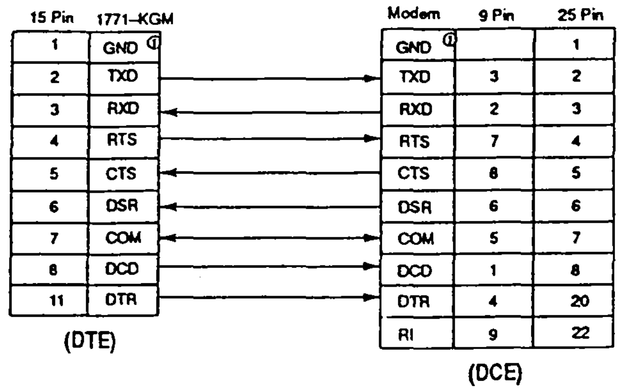


① You can also use cable 1747–CP3.

② Jumpers are only needed if you cannot disable the hardware handshaking on the port.

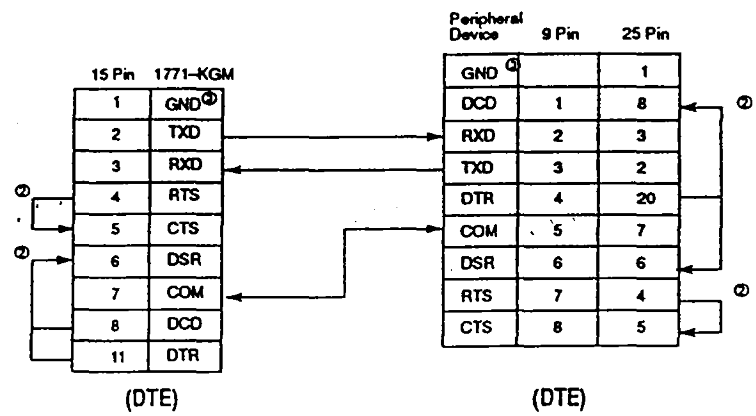
③ Connect the shield of the cable to the GND pin on one end only. Leave the other end open.

1771–KGM to a Modem (Hardware Handshaking Enabled)



① *Connect the shield of the cable to the GND pin on one end only. Leave the other end open.*

1771–KGM to a 5/03 Processor, IBM AT, 1770–KF3, 1775–KA, 1773–KA, 5130–RM, or PLC–5 (Hardware Handshaking Disabled) ①

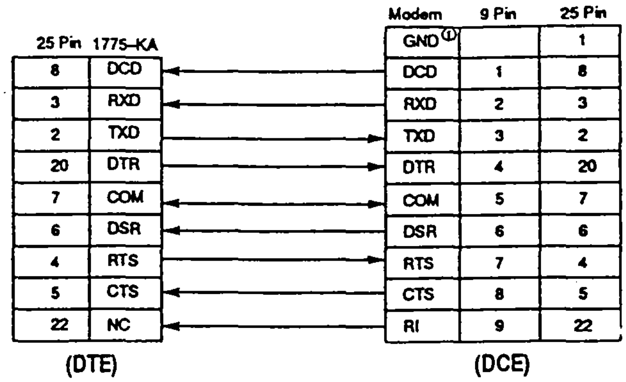


① *You can also use cable 1747–CP3.*

② *Jumpers are only needed if you cannot disable the hardware handshaking on the port.*

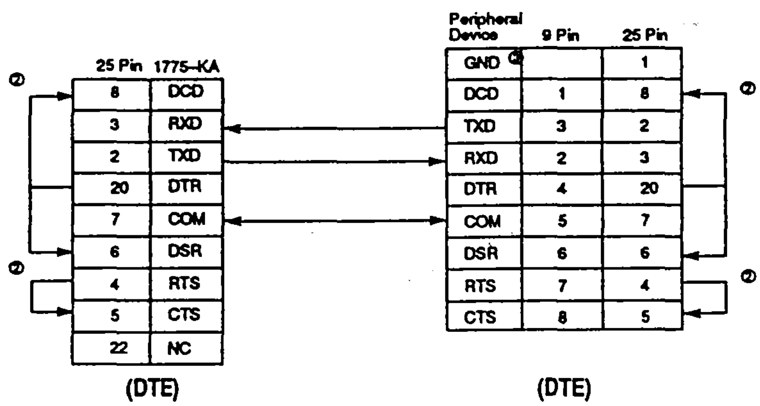
③ *Connect the shield of the cable to the GND pin on one end only. Leave the other end open.*

1775-KA to a Modem (Hardware Handshaking Enabled)



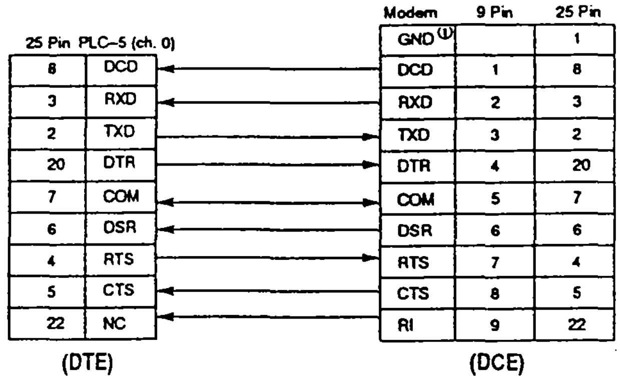
① *Connect to the shield of the cable.*

1775-KA to a 5/03 Processor, IBM AT, 1770-KF3, 1773-KA, 5130-RM, or PLC-5 (Hardware Handshaking Disabled) ①



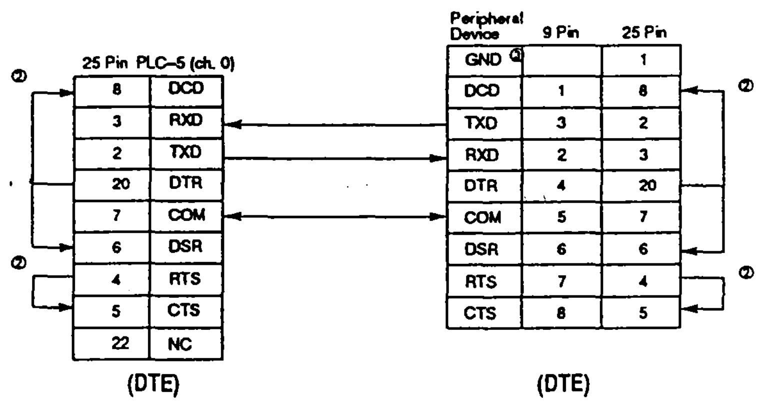
① *You can also use cable 1747-CP3.*
② *Jumpers are only needed if you cannot disable the hardware handshaking on the port.*
③ *Connect to the shield of the cable.*

PLC-5 (Channel 0) to a Modem (Hardware Handshaking Enabled)



① Connect to the shield of the cable.

PLC-5 (Channel 0) to a 5/03 Processor, IBM AT, 1770-KF3, 1773-KA, 5130-RM, PLC-5, 1747-KE, or 1746-BAS (Hardware Handshaking Disabled) ①

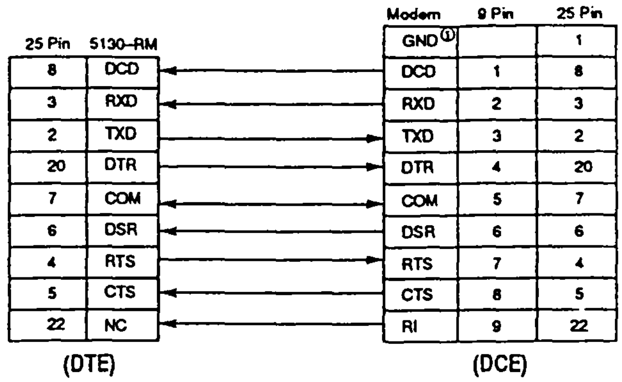


① You can also use cable 1747-CP3.

② Jumpers are only needed if you cannot disable the hardware handshaking on the port.

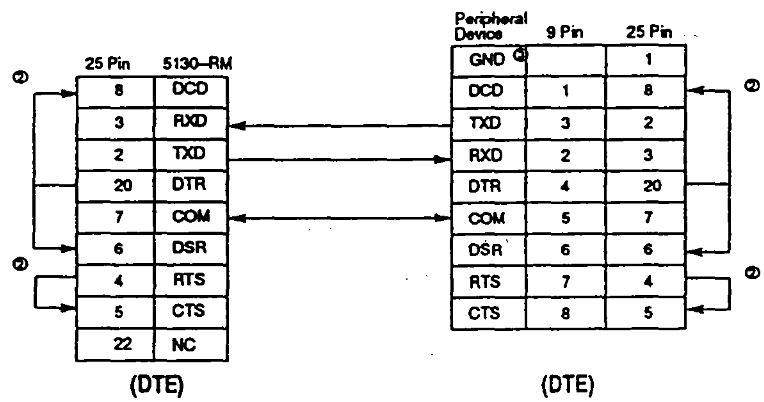
③ Connect to the shield of the cable.

5130–RM to a Modem (Hardware Handshaking Enabled)



① Connect to the shield of the cable.

5130–RM to a 5/03 Processor, IBM AT, 1770–KF3, 1773–KA, 5130–RM, PLC–5, 1747–KE, or 1746–BAS (Hardware Handshaking Disabled) ①



① You can also use cable 1747–CP3.
② Jumpers are only needed if you cannot disable the hardware handshaking on the port.
③ Connect to the shield of the cable.

Calculating Heat Dissipation for the SLC 500 Control System

This appendix will assist you in calculating the heat dissipation of your SLC 500 control system. It consists of the following:

- definition of key terms
- table and graphs
- example heat dissipation calculaion
- heat dissipation worksheet (page D–5)

To select an enclosure for your SLC 500 control system, refer to chapter 1.

Definition of Key Terms

The following terms are used throughout this appendix. Familiarize yourself with them before proceeding further into the appendix.

Watts per point — maximum heat dissipation that can occur in each field wiring point when energized.

Minimum watts — amount of heat dissipation that can occur when there is no field power present.

Maximum watts — maximum amount of heat that the module generates with field power present.

Module Heat Dissipation: Calculated Watts vs. Maximum Watts

There are two ways that you can calculate heat dissipation.

Calculated Watts — if you want to determine the amount of heat generated by the points energized on your module, use the formula below for calculating the heat dissipation of each module. Then use these values for calculating the heat dissipation of your control system, which is done using the worksheet.

(number of points energized x watts per point) + minimum watts = heat dissipation of module or controller

Maximum Watts — maximum amount of heat that the module generates with field power present. Use maximum watts especially if you are not sure how many points on a module will be energized at any time.

Once you have determined which way you will calculate the heat dissipation of your modules, see the Example Worksheet for Calculating Heat Dissipation on page D–4. This worksheet shows you how to calculate the heat dissipation for the example SLC control system also on page D–4. Once you feel comfortable with the layout of the worksheet, go to the worksheet on page D–5 and fill it out for your control system.

Use this Table to Calculate the Power Supply Loading

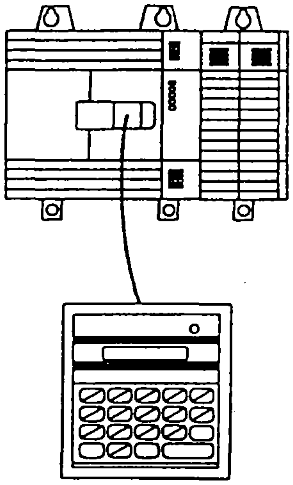
Use the table below to calculate the power supply loading for each chassis that you have (step 1 of the worksheet).

Hardware Component	Catalog Numbers	Watts per Point	Minimum Watts	Maximum Watts
Fixed Controllers	1747–L20A	0.27	10.5	15.0
	1747–L30A	0.27	12.7	19.2
	1747–L40A	0.27	14.3	23.0
	1747–L20B	0.27	9.9	17.0
	1747–L30B	0.27	11.6	22.0
	1747–L40B	0.27	13.0	27.0
	1747–L20C	0.20	17.4	21.0
	1747–L30C	0.20	18.7	24.0
	1747–L40C	0.20	19.9	27.0
	1747–L20D	0.20	12.4	19.0
	1747–L30D	0.20	13.9	23.0
	1747–L20E	0.20	12.6	18.0
	1747–L40E	0.20	16.0	27.0
	1747–L20F	0.20	5.0	9.0
	1747–L40F	0.20	7.4	15.0
	1747–L20G	0.20	4.4	10.0
	1747–L20L	0.20	12.1	18.0
	1747–L30L	0.20	14.0	23.0
	1747–L40L	0.20	16.0	27.0
	1747–L20N	0.20	4.4	10.0
	1747–L20P	0.35	8.8	17.0
	1747–L30P	0.35	10.5	23.0
	1747–L40P	0.35	11.6	28.0
	1747–L20R	0.35	10.5	16.0
Input Modules	1746–IA4	0.27	0.175	1.30
	1746–IA8	0.27	0.250	2.40
	1746–IA16	0.27	0.425	4.80
	1746–IM4	0.35	0.175	1.60
	1746–IM8	0.35	0.250	3.10
	1746–IM16	0.35	0.425	6.00
	1746–IB8	0.20	0.250	1.90
	1746–IB16	0.20	0.425	3.60
	1746–IB32	0.20	0.530	6.90
	1746–IV8	0.20	0.250	1.90
	1746–IV16	0.20	0.425	3.60
	1746–IV32	0.20	0.530	6.90
	1746–IG16	0.020	0.700	1.00
	1746–IN16	0.35	0.425	6.00
Output Modules	1746–OA8	1.00	0.925	9.00
	1746–OA16	0.462	1.85	9.30
	1746–OB8	0.775	0.675	6.90
	1746–OB16	0.338	1.40	7.60
	1746–OB32	0.078	2.26	4.80
	1746–OV8	0.775	0.675	6.90

Hardware Component	Catalog Numbers	Watts per Point	Minimum Watts	Maximum Watts
Output Modules	1746–OV16	0.388	1.40	7.60
	1746–OV32	0.078	2.26	4.80
	1746–OW4	0.133	1.31	1.90
	1746–OW8	0.138	2.59	3.70
	1746–OW16	0.033	5.17	5.70
	1746–OX8	0.825	2.59	8.60
	1746–OG16	0.033	0.900	1.50
Input & Output Modules	1746–IO4	0.27 — per input pt. 0.133 — per output pt.	0.75	1.60
	1746–IO8	0.27 — per input pt. 0.133 — per output pt.	1.38	3.00
	1746–IO12	0.27 — per input pt. 0.133 — per output pt.	2.13	4.60
Specialty Modules	1746–NI4	NA	2.17	2.2
	1746–NIO4I	NA	3.76	3.8
	1746–NIO4V	NA	3.04	3.1
	1746–NO4I	NA	4.96	5.0
	1746–NO4V	NA	3.78	3.8
	1746–BAS	NA	3.75	3.8
	1747–DCM	NA	1.8	1.8
	1747–DSN	NA	4.5	4.5
	1747–KE	NA	3.75	3.8
Peripheral Devices	1747–AIC	NA	2.0	2.0
	1747–DTAM	NA	2.5	2.5
	1747–PT1 Series A & B	NA	2.5	2.5
	1747–PIC	NA	2.0	2.0

NA — Not Applicable

Example Heat Dissipation Calculation



If your controller consisted of the following hardware components, you would calculate heat dissipation as shown in the *example* worksheet below.

Hardware Components	Catalog Number	Minimum Watts	Maximum Watts
Fixed Controller	1747–L20A	10.5	15.0
Input Module	1746–IA16	0.425	4.8
Output Module	1746–OA16	1.85	9.3
Peripheral Device	1747–DTAM	2.5	2.5

Example Worksheet for Calculating Heat Dissipation

Procedure	Heat Dissipation
1. Calculate the *heat dissipation* for your fixed controller. Write in the watts (calculated watts or maximum watts, see page D–1) dissipated by the controller, I/O and specialty modules, and peripheral device attached to the controller. Add these values together. Catalog Number / Heat Dissipation Fixed Controller: L20A / 15 Expansion Chassis Slot 1 (if applicable): IA16 / 4.8 Slot 2 (if applicable): OA16 / 9.3 Peripheral Device: DTAM / 2.5 Total: 31.6 *Place Total on this Line* ⟶	31.6 W
2. Convert to BTUs/hr. Multiply the total heat dissipation of your SLC 500 fixed control system by 3.414.	x 3.414

Total heat dissipation of the SLC 500 control system: 107.9 **BTUs/hr**

Worksheet for Calculating Heat Dissipation

Use this worksheet to calculate the heat dissipation for your fixed controller.

Procedure	Heat Dissipation
1. **Calculate the *heat dissipation* for your fixed controller.** Write in the watts (calculated watts or maximum watts, see page D–1) dissipated by the controller, I/O and specialty modules, and peripheral device attached to the controller. Add these values together. Catalog Number / Heat Dissipation Fixed Controller ________ ________ Expansion Chassis Slot 1 (if applicable) ________ ________ Slot 2 (if applicable) ________ ________ Peripheral Device ________ ________ Total: ________ *Place Total on this Line* ——>	________ W
2. **Convert to BTUs/hr. Multiply the total heat dissipation of your SLC 500 fixed control system by 3.414.**	x 3.414

Total heat dissipation of the SLC 500 control system: ________ **BTUs/hr**

Appendix E

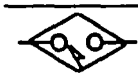
Wiring and Circuit Diagrams and Voltage Ranges for Your Fixed Controller

This appendix covers the following for your fixed controller.

- wiring diagrams
- circuit diagrams
- voltage ranges

Wiring Symbols

The following table provides an explanation of the symbols used in the wiring diagrams. The symbols do not indicate the only type of I/O devices that can be connected, but rather a "typical" device. As long as your I/O device meets the I/O circuit specifications, it should be compatible.

This Symbol	Represents Typical Input Device
	Mechanical switch
	Solid–state switch

This Symbol	Represents Typical Output Device
	Solenoid
	Control relay

The connections illustrated in the wiring diagrams are shown for example purposes only.

- You can connect I/O devices in any order to the I/O circuits. If you are not going to load all of your circuits, space the connections evenly apart to help in heat dissipation.
- All the input circuits on any one fixed controller are the same with one exception: input 0 is unique for all fixed controllers which have 24 VDC input circuits. In this case, input 0 can be used as a high–speed counter. The diagrams in this appendix show the differences in operating characteristics.
- All the output circuits on any one fixed controller are the same.

In the wiring diagrams for the fixed controller with 24 VDC input circuits and 120/240 VAC line power, the User Power Source (terminals next to Power Supply terminals — "PWR OUT 24 VDC" and "PWR OUT COM", is shown to power some input devices. This is optional. The User Power Source can provide up to 200mA at 24 VDC for input devices.

Wiring and Circuit Diagrams and Voltage Range Locations

Use the table below to locate the appropriate wiring and circuit diagrams and voltage ranges.

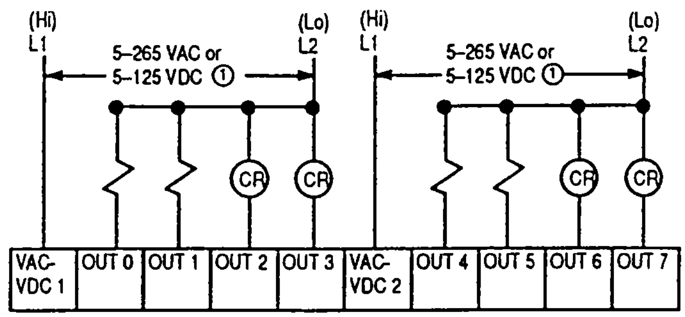
Catalog Numbers	Description①	Wiring Diagram	Input Circuit Diagram	On/Off State Voltage	Output Circuit Diagram	Operating Voltage Range
1747–L20A	(12) 120 VAC Inputs and (8) Relay Outputs	E–4	E–5	E–5	E–5	E–5
1747–L20B	(12) 120 VAC Inputs and (8) Triac Outputs	E–6	E–7	E–7	E–7	E–7
1747–L20C	(12) 24 VDC Sinking Inputs, High–Speed Counter Input and (8) Relay Outputs	E–8	E–9	E–9	E–10	E–10
1747–L20D	(12) 24 VDC Sinking Inputs, High–Speed Counter Input and (8) Triac Outputs	E–11	E–12	E–12	E–13	E–13
1747–L20E	(12) 24 VDC Sinking Inputs, High–Speed Counter Input and (8) Transistor Sourcing Outputs	E–14	E–15	E–15	E–16	E–16
1747–L20F	(12) 24 VDC Sinking Inputs, High–Speed Counter Input and (8) Relay Outputs	E–17	E–18	E–18	E–19	E–19
1747–L20G	(12) 24 VDC Sinking Inputs, High–Speed Counter Input and (8) Transistor Sourcing Outputs	E–20	E–21	E–21	E–22	E–22
1747–L20L	(12) 24 VDC Sourcing Inputs, High–Speed Counter Input and (8) Transistor Sinking Outputs	E–23	E–24	E–24	E–25	E–25
1747–L20N	(12) 24 VDC Sourcing Inputs, High–Speed Counter Input and (8) Transistor Sinking Outputs	E–26	E–27	E–27	E–28	E–28
1747–L20P	(12) 240 VAC Inputs and (8) Triac Outputs	E–29	E–30	E–30	E–30	E–30
1747–L20R	(12) 240 VAC Inputs and (8) Relay Outputs	E–31	E–32	E–32	E–32	E–32
1747–L30A	(18) 120 VAC Inputs and (12) Relay Outputs	E–33	E–34	E–34	E–34	E–34
1747–L30B	(18) 120 VAC Inputs and (12) Triac Outputs	E–35	E–36	E–36	E–36	E–36
1747–L30C	(18) 24 VDC Sinking Inputs, High–Speed Counter Input and (12) Relay Outputs	E–37	E–38	E–38	E–39	E–39
1747–L30D	(18) 24 VDC Sinking Inputs, High–Speed Counter Input and (12) Triac Outputs	E–40	E–41	E–41	E–42	E–42
1747–L30L	(18) 24 VDC Sourcing Inputs, High–Speed Counter Input and (12) Transistor Sinking Outputs	E–43	E–44	E–44	E–45	E–45
1747–L30P	(18) 240 VAC Inputs and (12) Triac Outputs	E–46	E–47	E–47	E–47	E–47
1747–L40A	(24) 120 VAC Inputs and (16) Relay Outputs	E–48	E–49	E–49	E–49	E–49

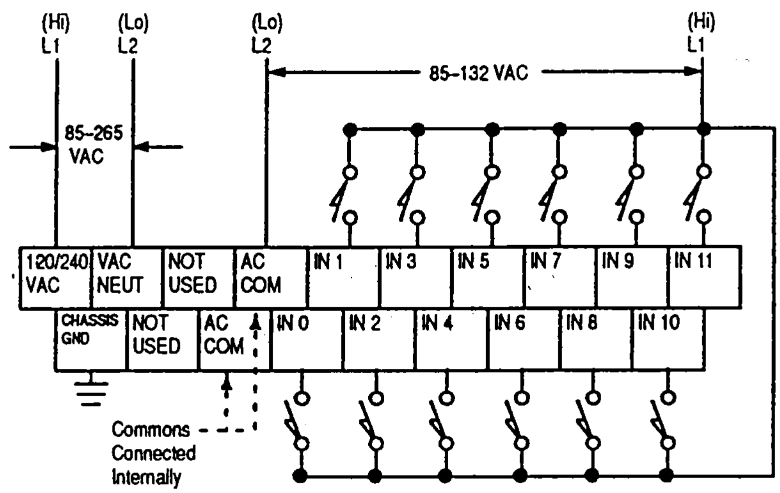
Catalog Numbers	Description[1]	Wiring Diagram	Input Circuit Diagram	On/Off State Voltage	Output Circuit Diagram	Operating Voltage Range
1747–L40B	(24) 120 VAC Inputs and (16) Triac Outputs	E–50	E–51	E–51	E–51	E–51
1747–L40C	(24) 24 VDC Sinking Inputs, High–Speed Counter Input and (16) Relay Outputs	E–52	E–53	E–53	E–54	E–54
1747–L40E	(24) 24 VDC Sinking Inputs, High–Speed Counter Input and (16) Transistor Sourcing Outputs	E–55	E–56	E–56	E–57	E–57
1747–L40F	(24) 24 VDC Sinking Inputs, High–Speed Counter Input and (16) Relay Outputs	E–58	E–59	E–59	E–60	E–60
1747–L40L	(24) 24 VDC Sourcing Inputs, High–Speed Counter Input and (16) Transistor Sinking Outputs	E–61	E–62	E–62	E–63	E–63
1747–L40P	(24) 240 VAC Inputs and (16) Triac Outputs	E–64	E–65	E–65	E–65	E–65

[1] *Refer to page 1–5 for line power specifications.*

Catalog Number 1747–L20A (12) 120 VAC Inputs & (8) Relay Outputs

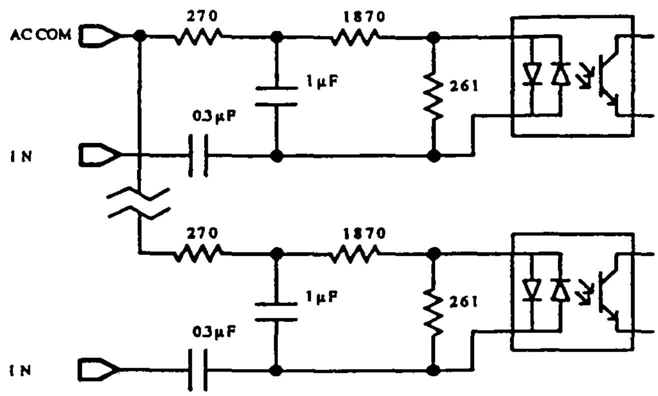
Wiring Diagram



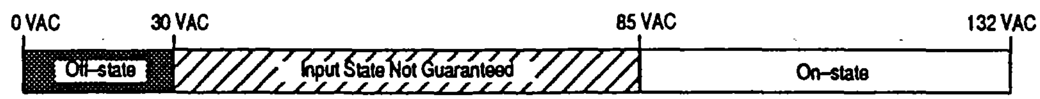


① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

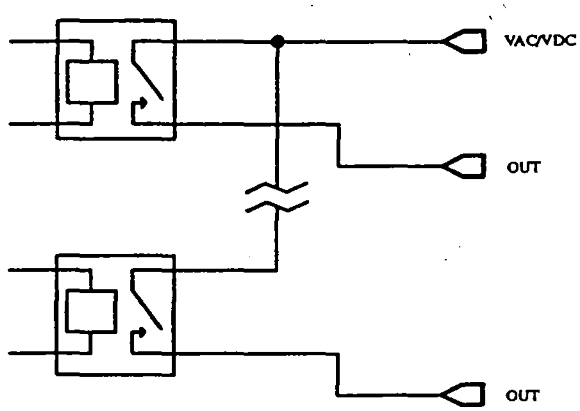
Input Circuit Diagram



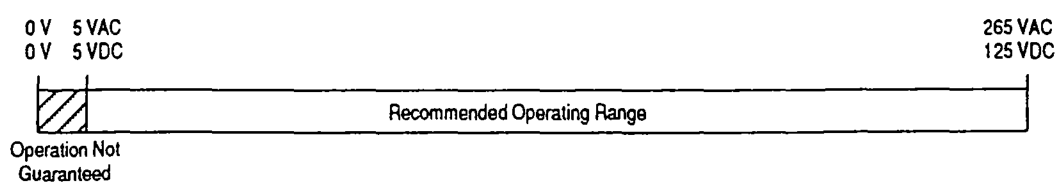
On/Off State Voltage Ranges



Output Circuit Diagram

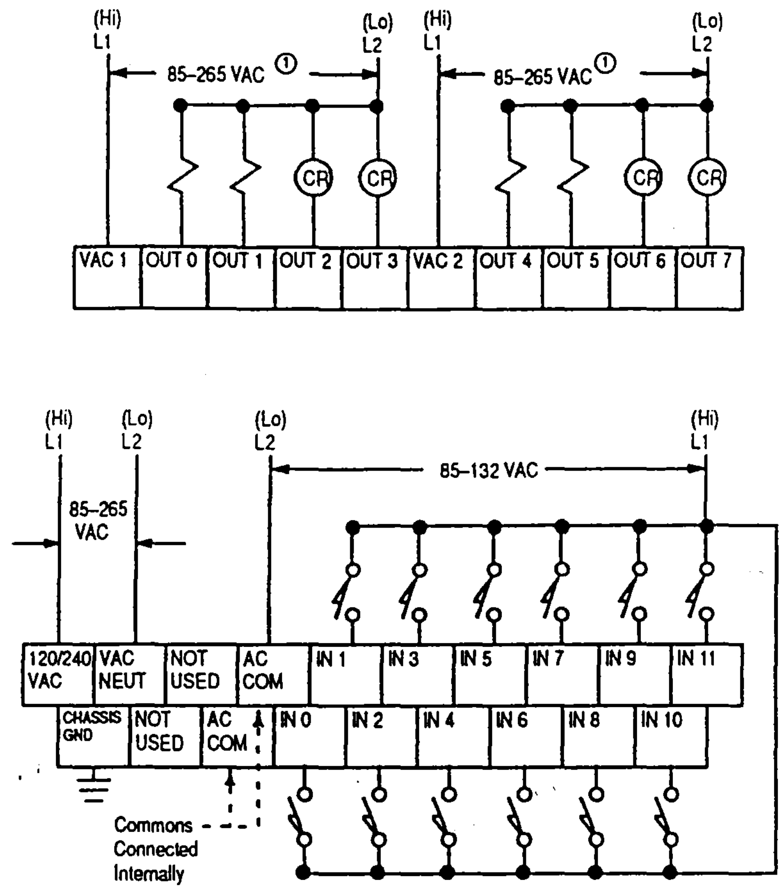


Operating Voltage Range



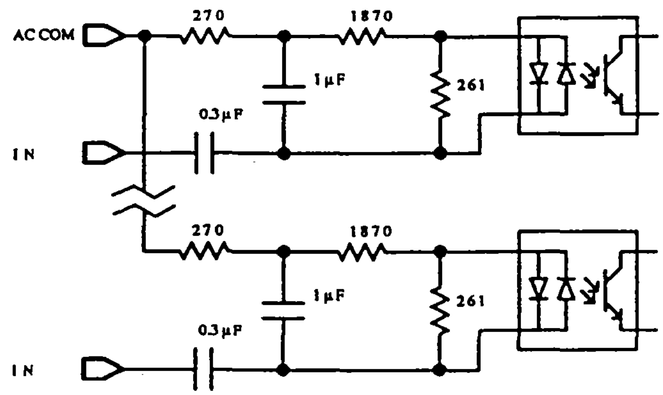
Catalog Number 1747–L20B (12) 120 VAC Inputs & (8) Triac Outputs

Wiring Diagram



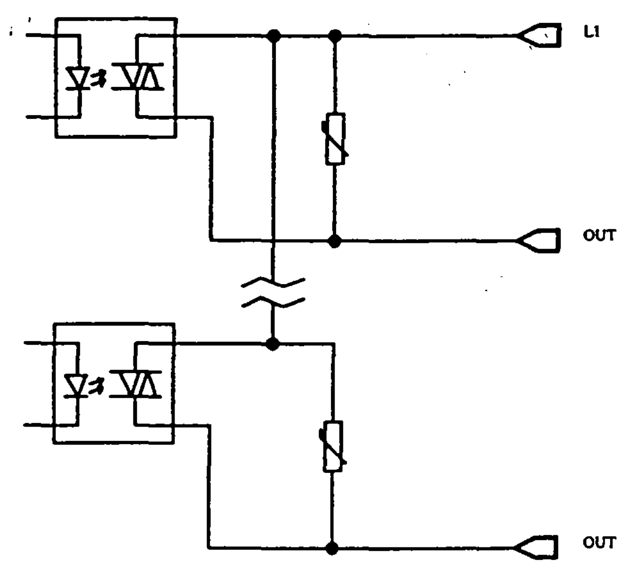
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

Input Circuit Diagram

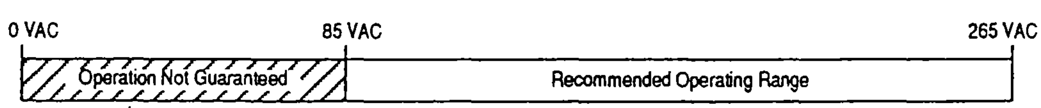


On/Off State Voltage Ranges

Output Circuit Diagram



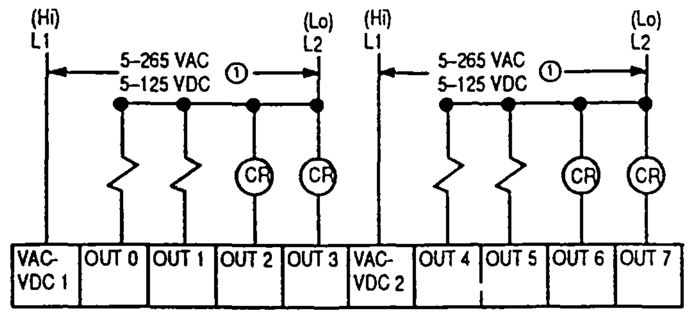
Operating Voltage Range

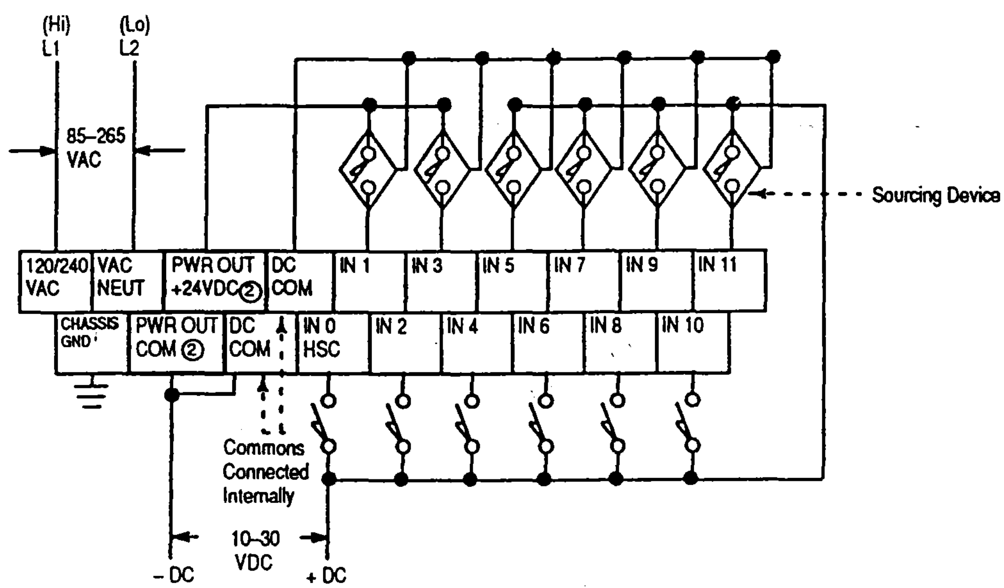


Important: If you measure the voltage at an output terminal that is not connected to a load or is connected to a high-impedanc load, you may measure as much as 100 VAC even though the output is off.

Catalog Number 1747–L20C (12) 24 VDC Sinking Inputs, High–Speed Counter Input & (8) Relay Outputs

Wiring Diagram

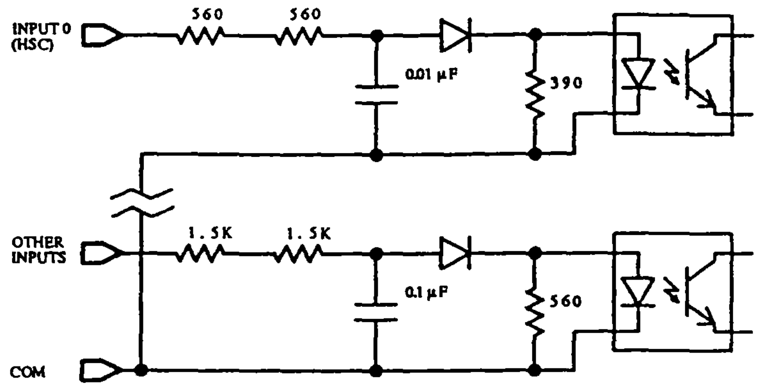




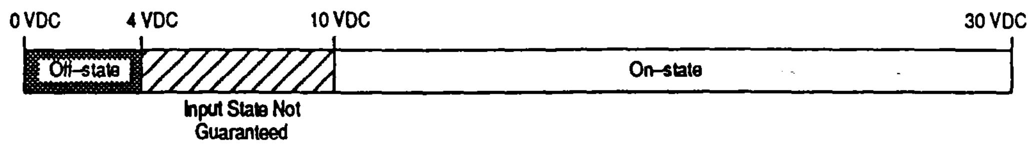
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

② *24 VDC, 200mA user power is available for sensors.*

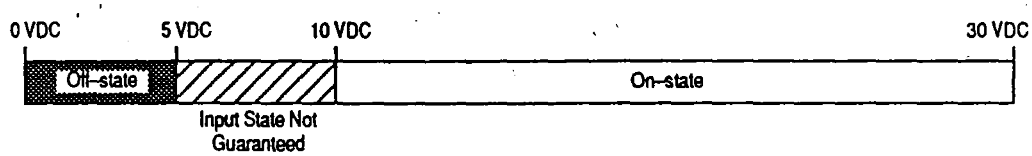
Input Circuit Diagram



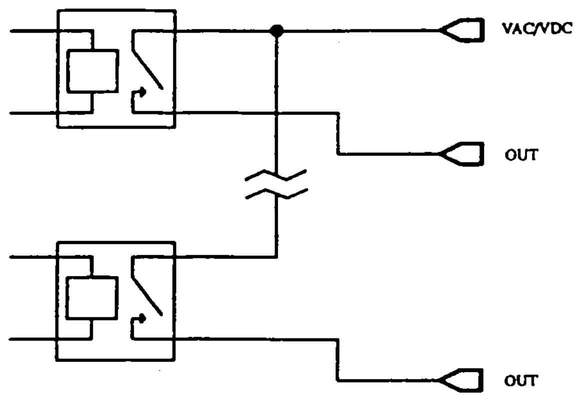
On/Off State Voltage Ranges – Input 0 (HSC)



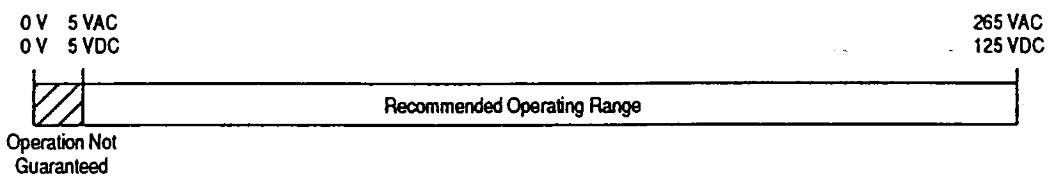
On/Off State Voltage Ranges – All Other Inputs



Output Circuit Diagram

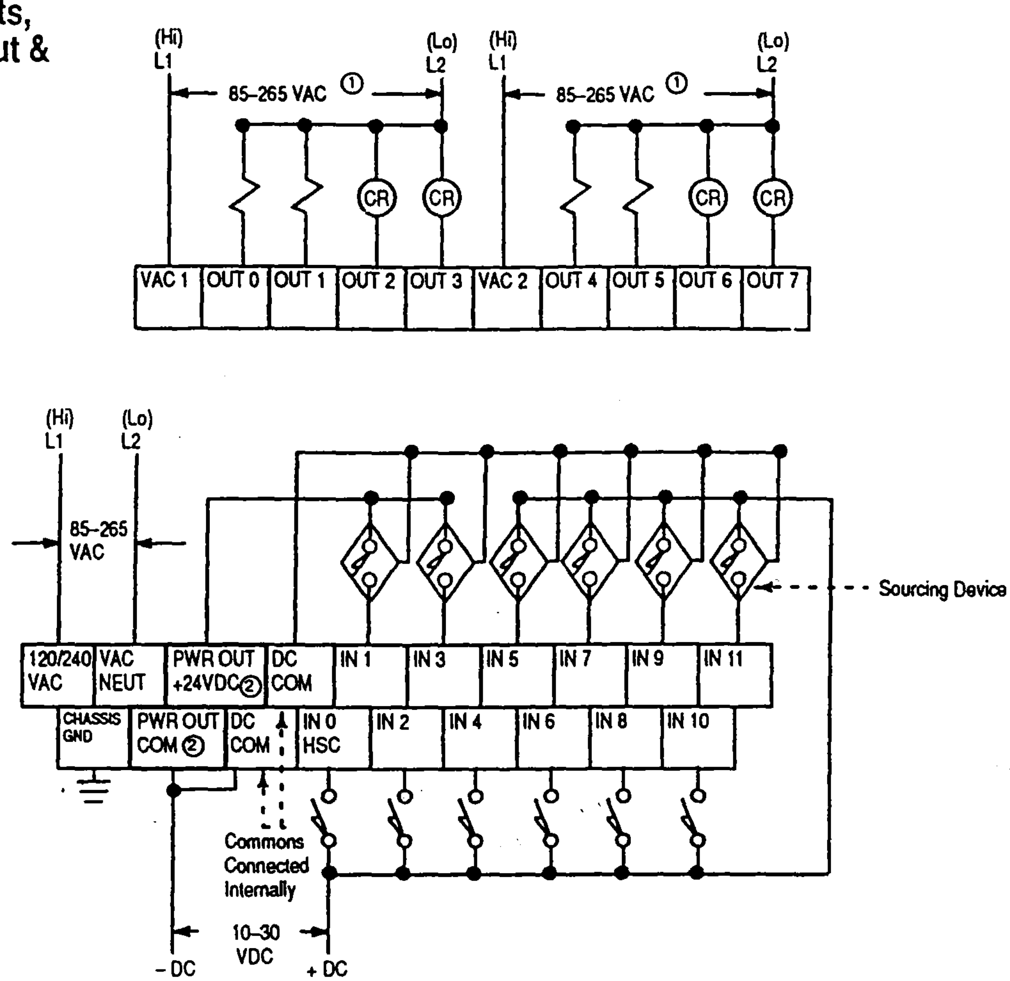


Operating Voltage Range



Catalog Number 1747-L20D (12) 24 VDC Sinking Inputs, High-Speed Counter Input & (8) Triac Outputs

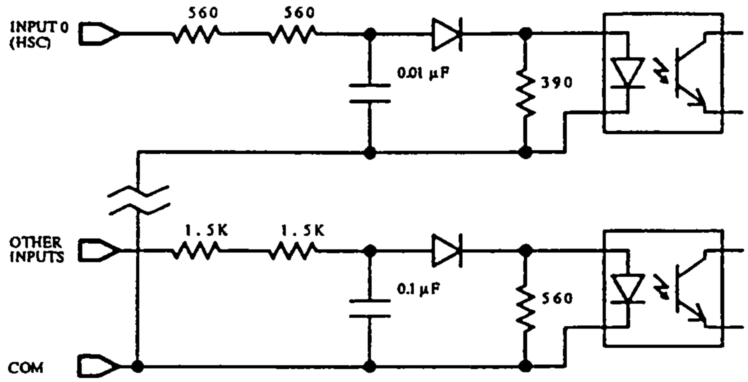
Wiring Diagram



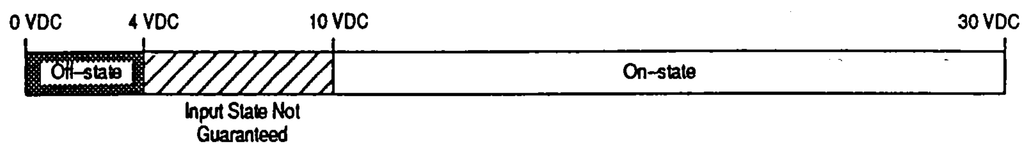
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

② *24 VDC, 200mA user power is available for sensors.*

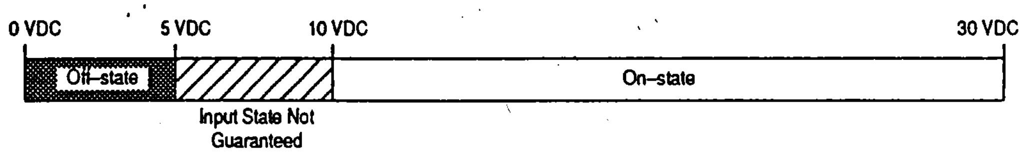
Input Circuit Diagram



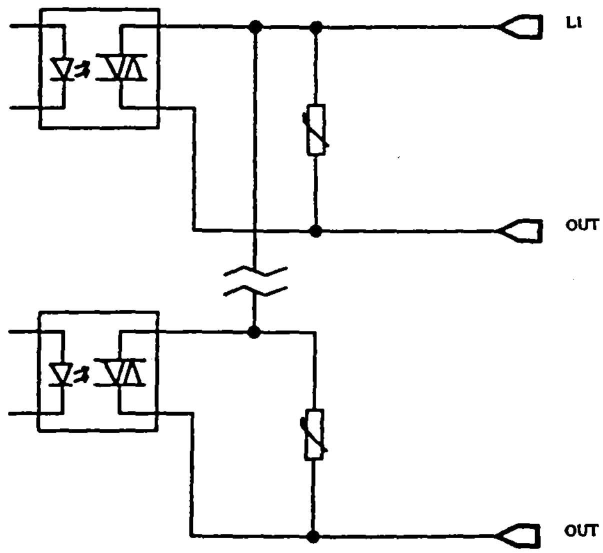
On/Off State Voltage Ranges – Input 0 (HSC)



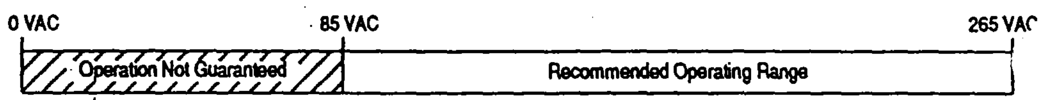
On/Off State Voltage Ranges – All Other Inputs



Output Circuit Diagram



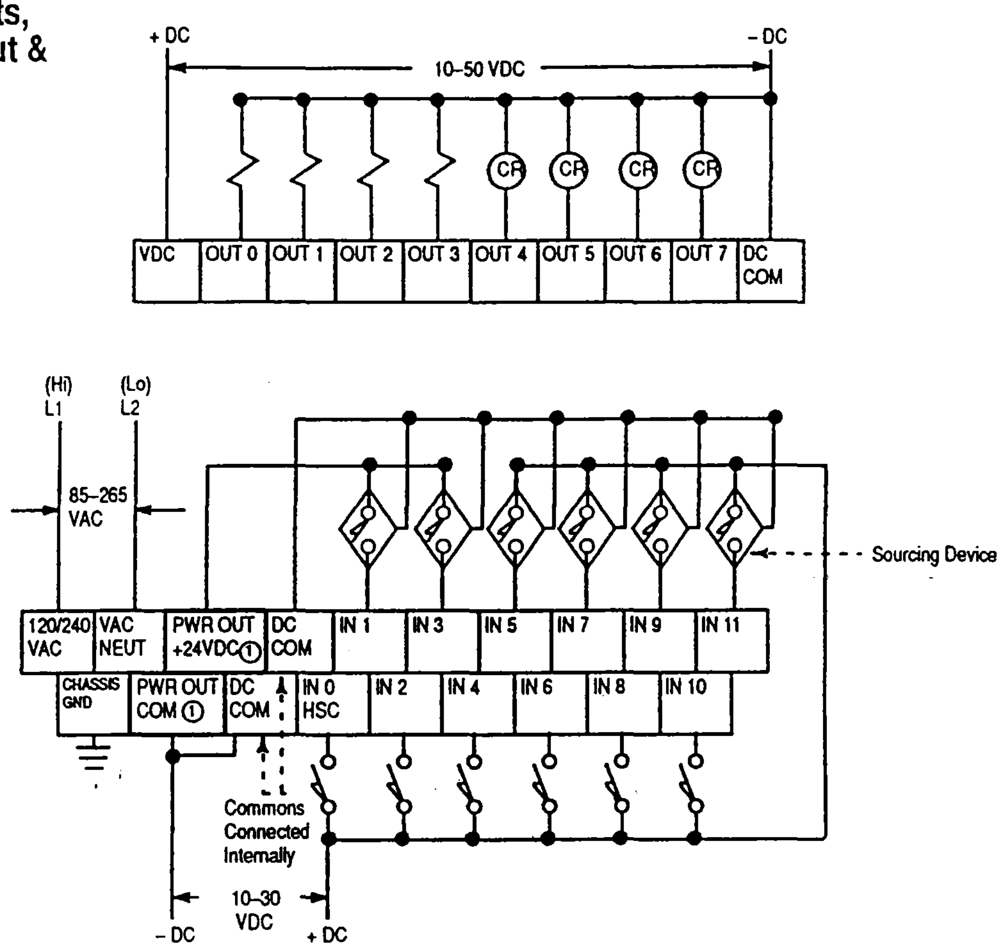
Operating Voltage Range



Important: If you measure the voltage at an output terminal that is not connected to a load or is connected to a high–impedance load, you may measure as much as 100 VAC even though the output is off.

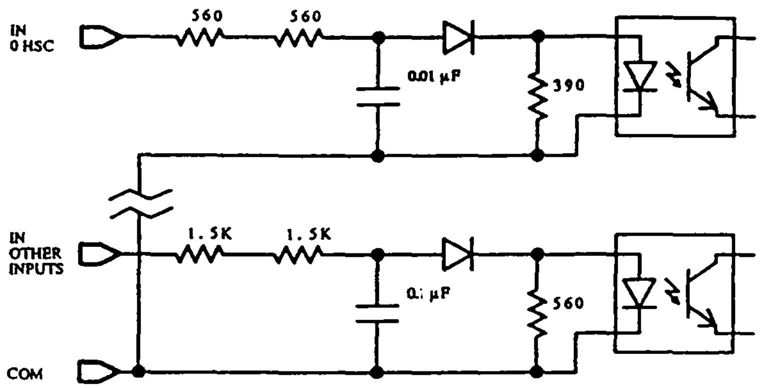
Catalog Number 1747–L20E (12) 24 VDC Sinking Inputs, High–Speed Counter Input & (8) Transistor Sourcing Outputs

Wiring Diagram

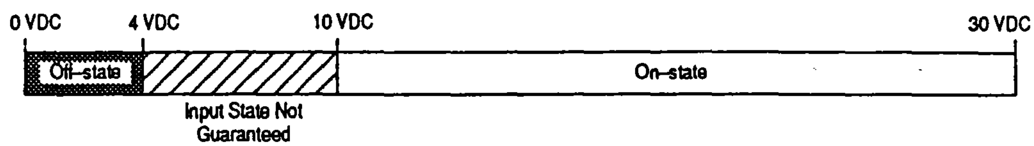


① *24 VDC, 200mA user power is available for sensors.*

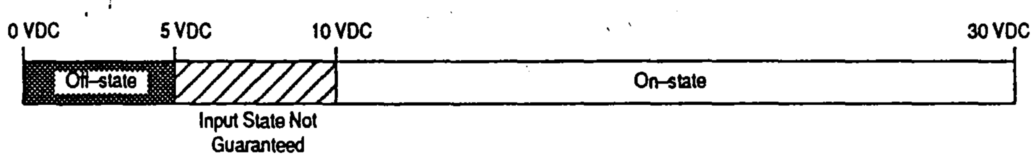
Input Circuit Diagram



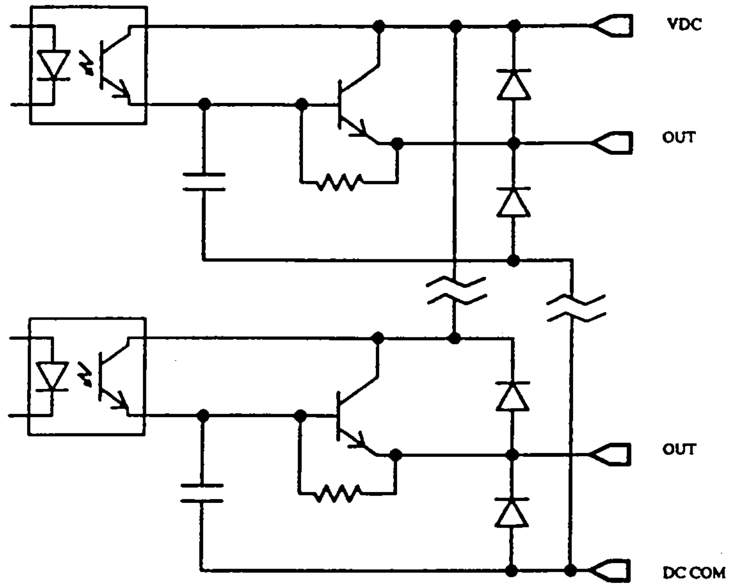
On/Off State Voltage Ranges – Input 0 (HSC)



On/Off State Voltage Ranges – All Other Inputs

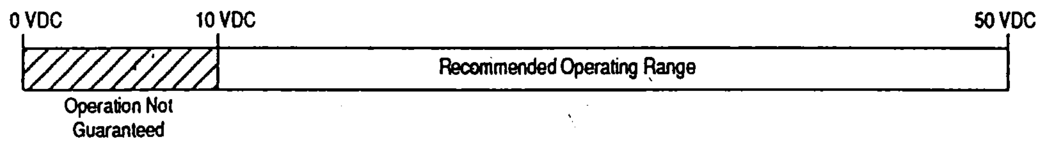


Output Circuit Diagram



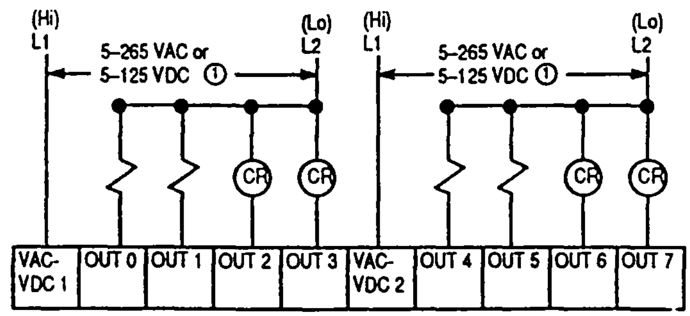
Operating Voltage Range

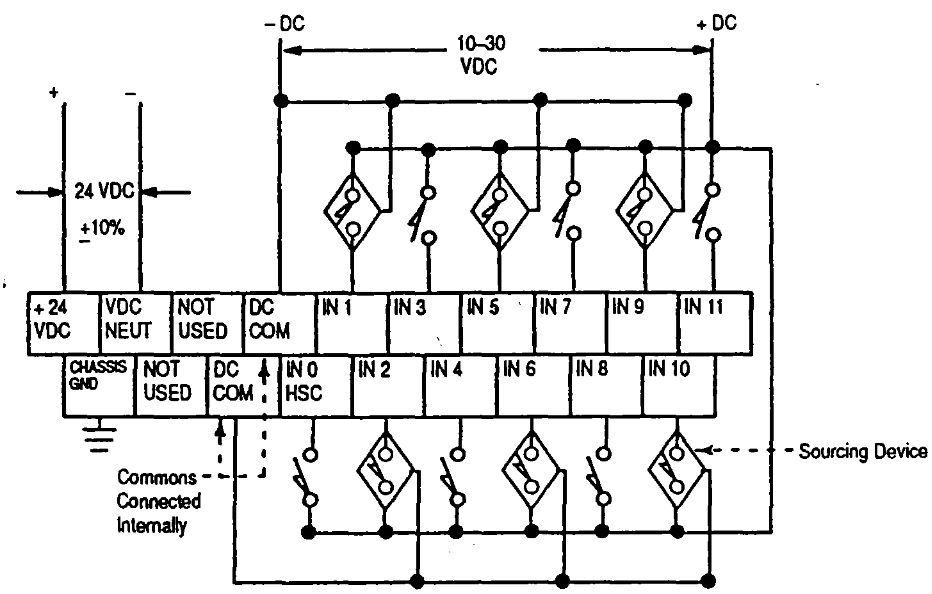
(Voltage is applied between +VDC and DC common.)



Catalog Number 1747–L20F (12) 24 VDC Sinking Inputs, High–Speed Counter Input & (8) Relay Outputs

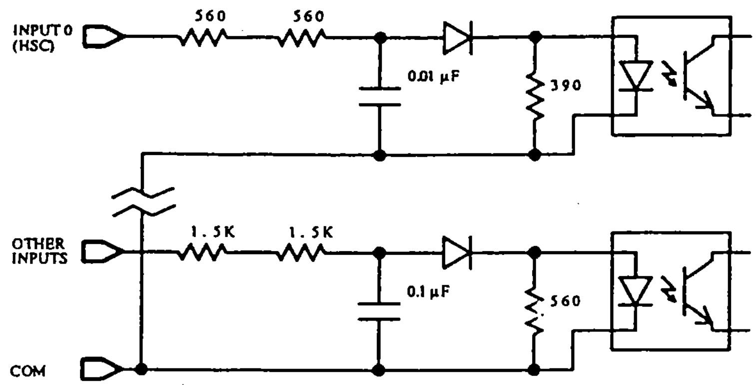
Wiring Diagram



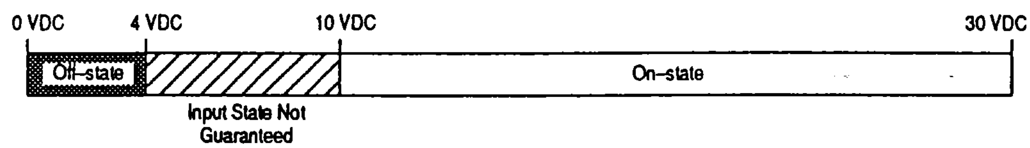


① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

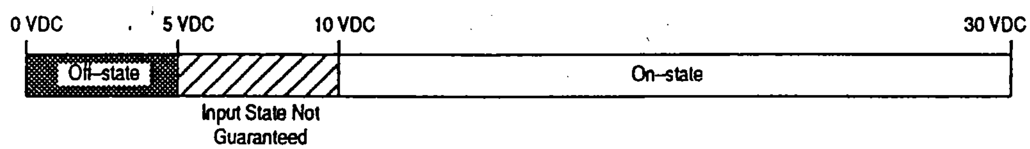
Input Circuit Diagram



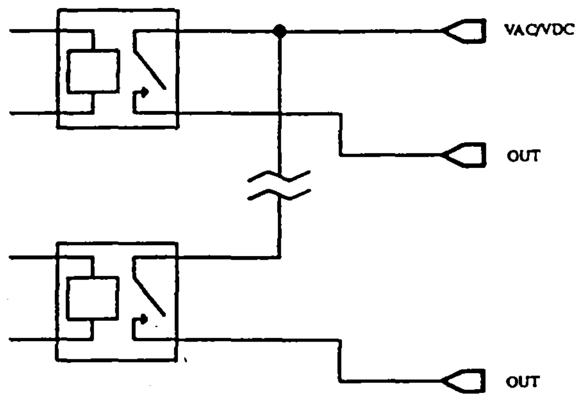
On/Off State Voltage Ranges – Input 0 (HSC)



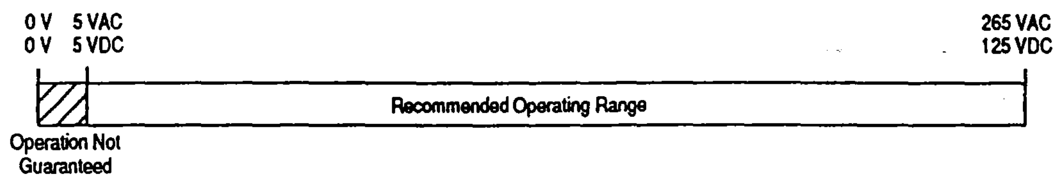
On/Off State Voltage Ranges – All Other Inputs



Output Circuit Diagram

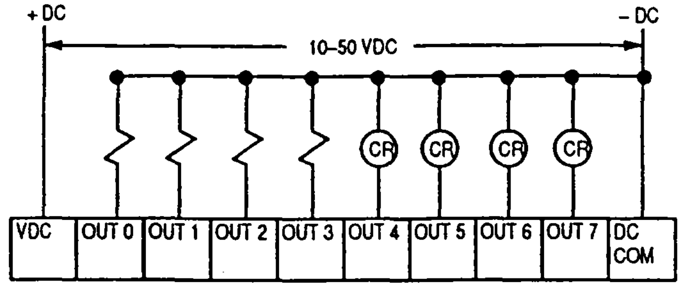


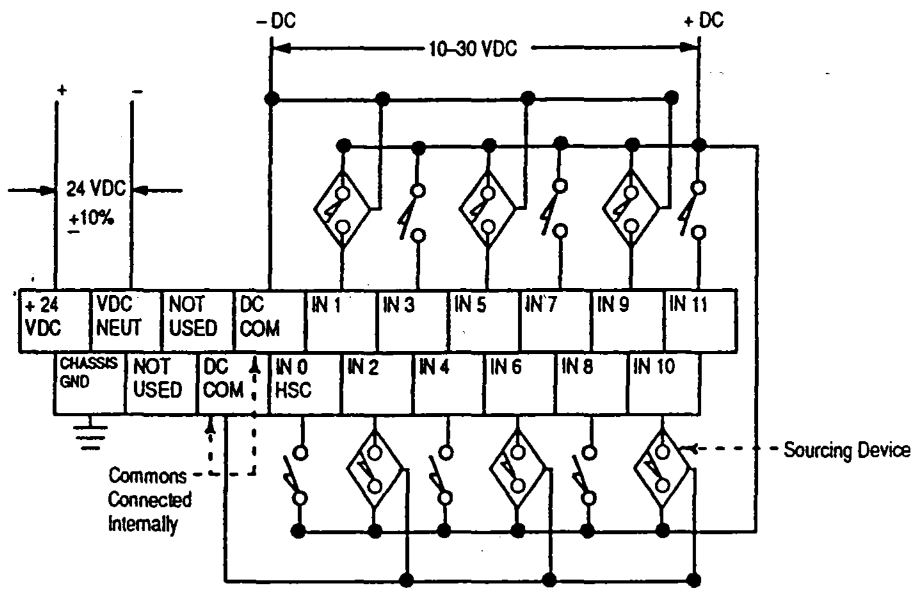
Operating Voltage Range



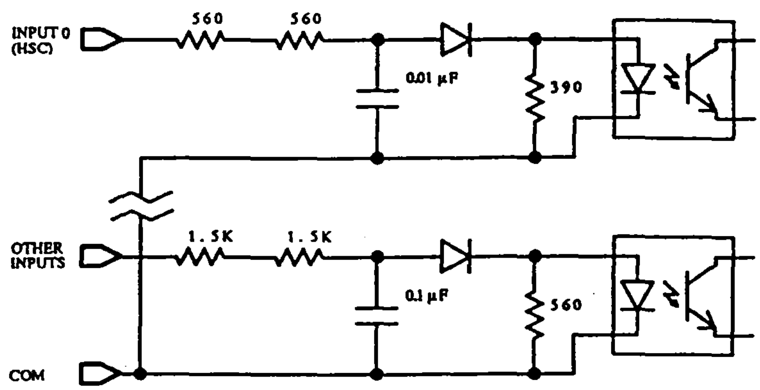
Catalog Number 1747–L20G (12) 24 VDC Sinking Inputs, High–Speed Counter Input & (8) Transistor Sourcing Outputs

Wiring Diagram

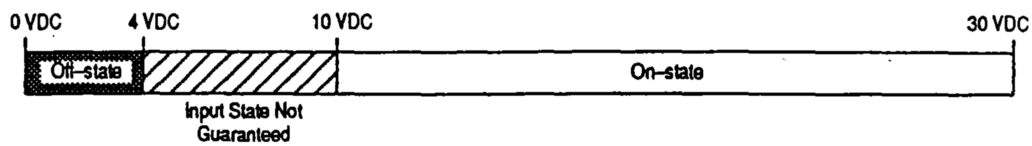




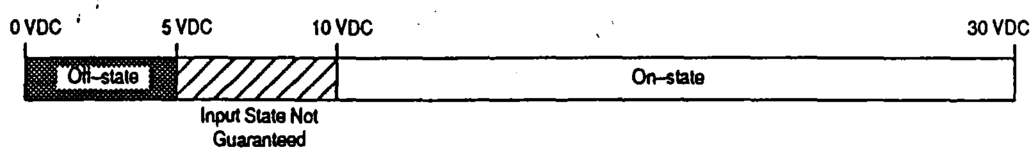
Input Circuit Diagram



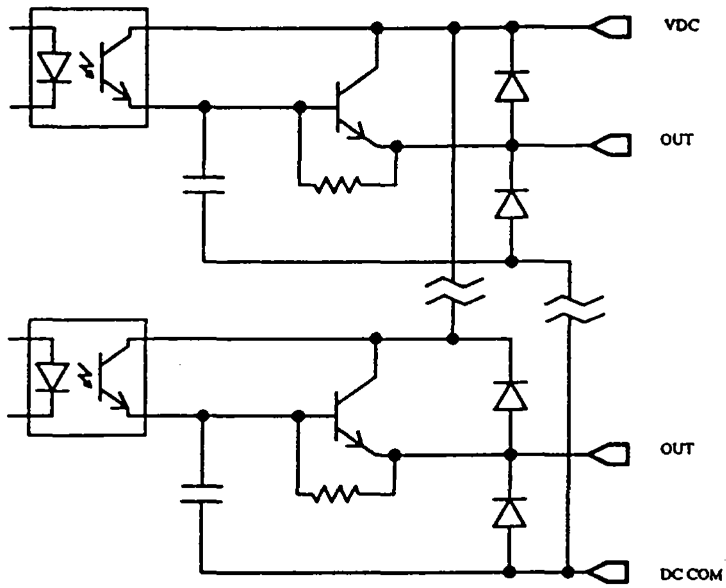
On/Off State Voltage Ranges – Input 0 (HSC)



On/Off State Voltage Ranges – All Other Inputs

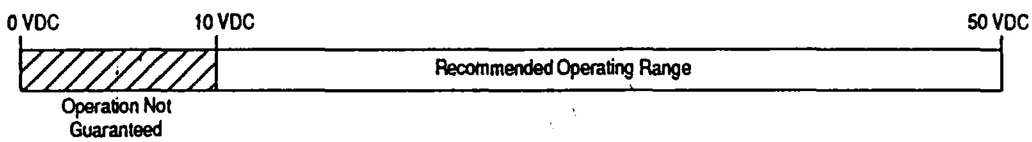


Output Circuit Diagram



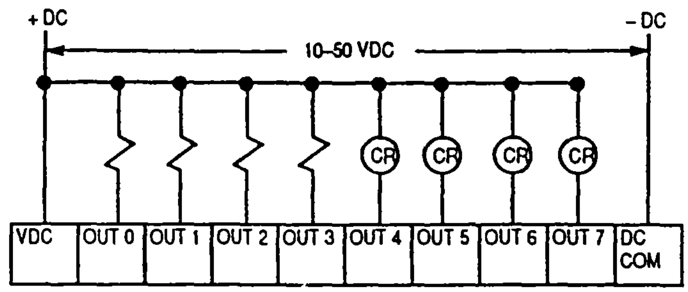
Operating Voltage Range

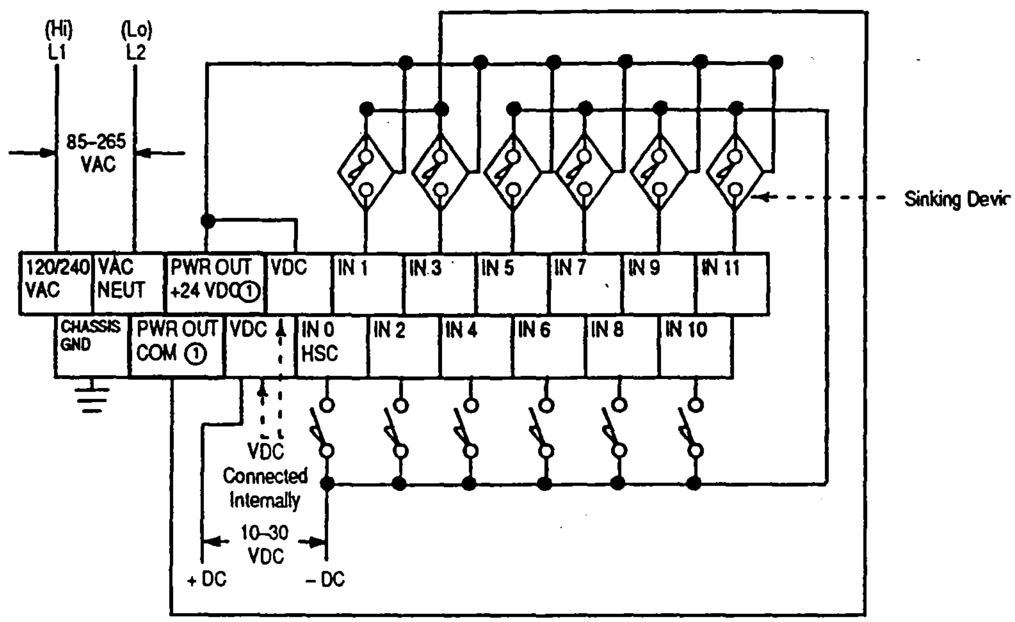
(Voltage is applied between +VDC and DC common.)



Catalog Number 1747–L20L (12) 24 VDC Sourcing Inputs, High–Speed Counter Input & (8) Transistor Sinking Outputs

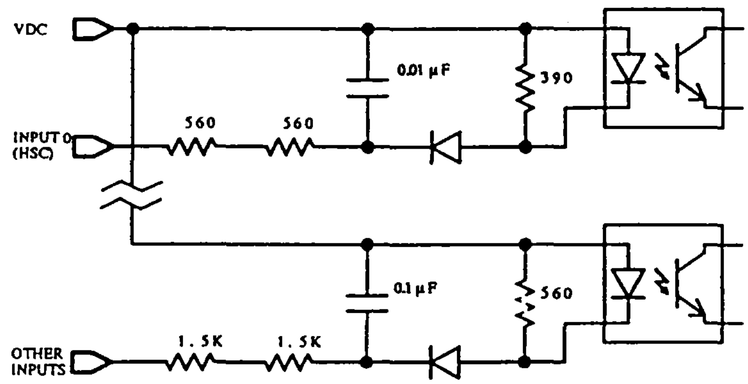
Wiring Diagram



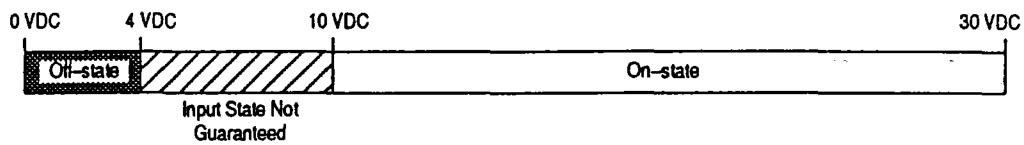


① 24 VDC, 200mA user power is available for sensors.

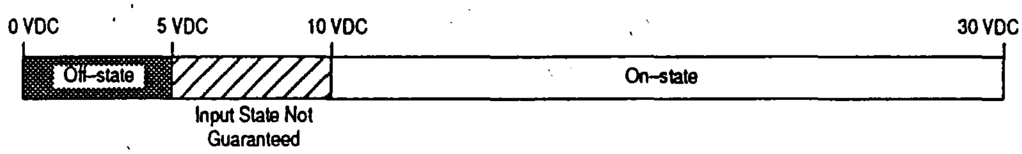
Input Circuit Diagram



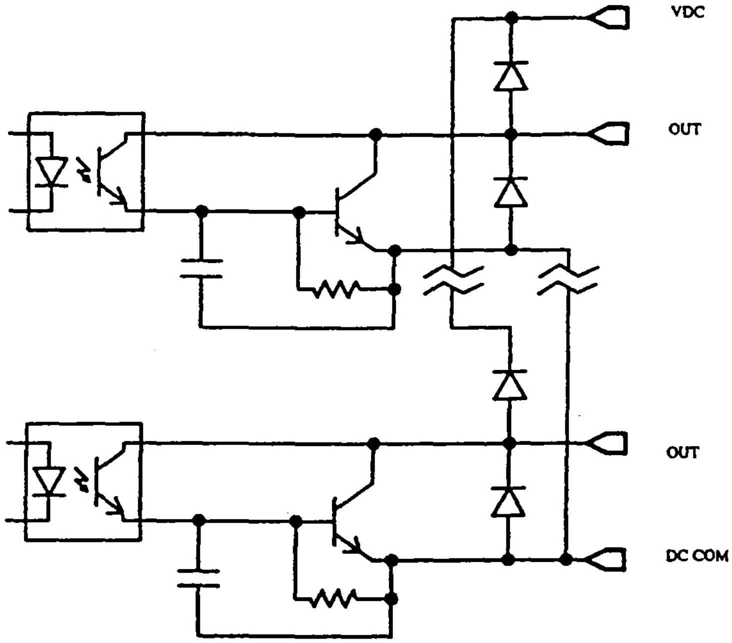
On/Off State Voltage Ranges – Input 0 (HSC)



On/Off State Voltage Ranges – All Other Inputs

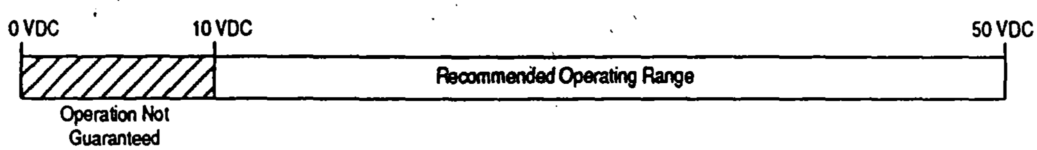


Output Circuit Diagram



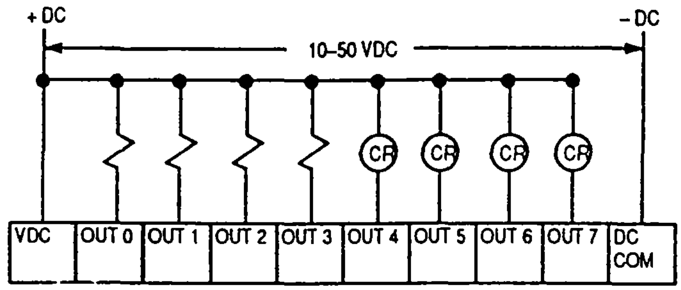
Operating Voltage Range

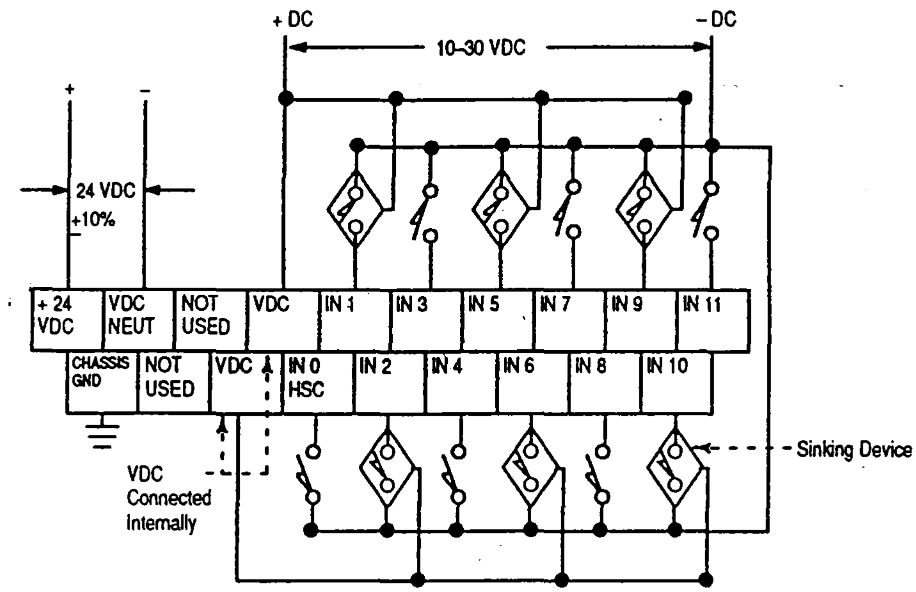
(Voltage is applied between +VDC and DC common.)



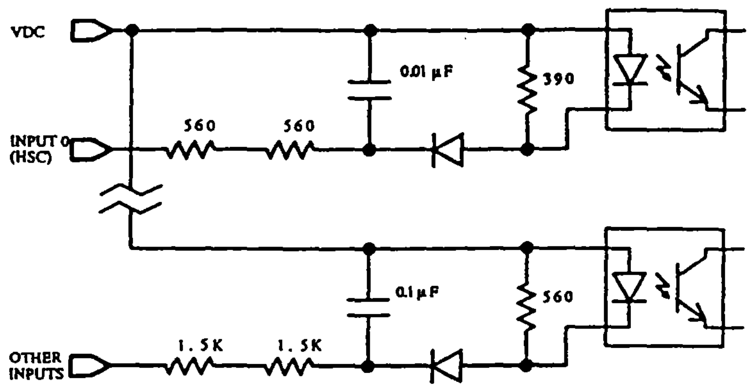
Catalog Number 1747–L20N (12) 24 VDC Sourcing Inputs, High–Speed Counter Input & (8) Transistor Sinking Outputs

Wiring Diagram

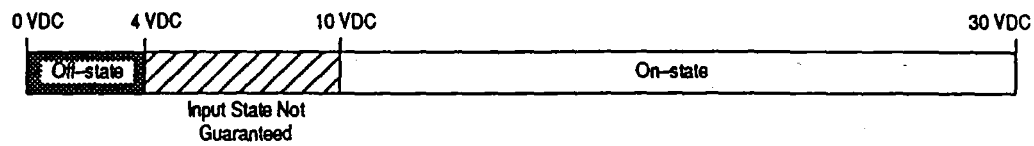




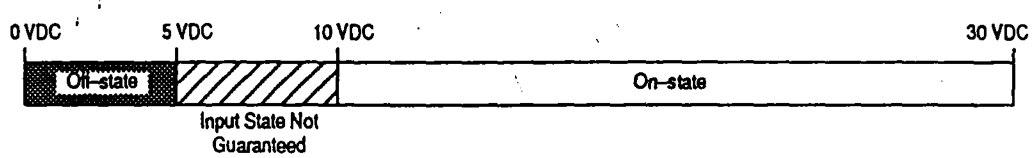
Input Circuit Diagram



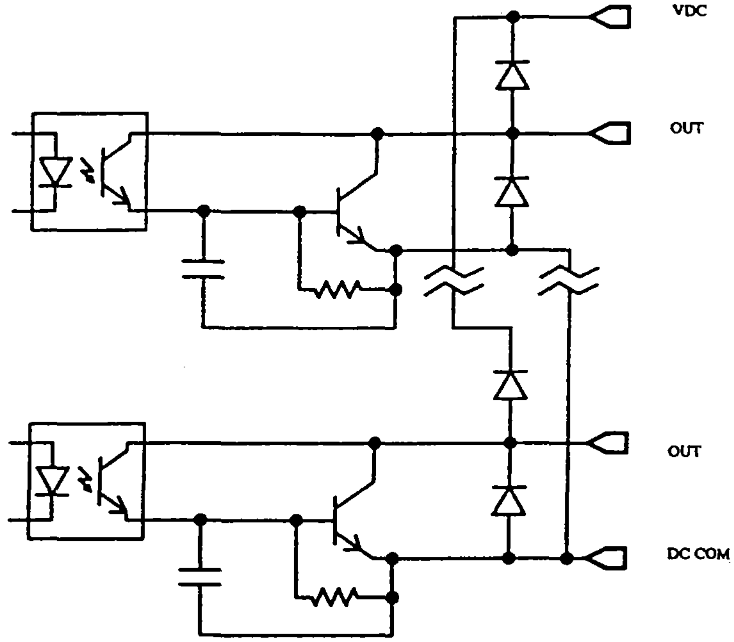
On/Off State Voltage Ranges – Input 0 (HSC)



On/Off State Voltage Ranges – All Other Inputs

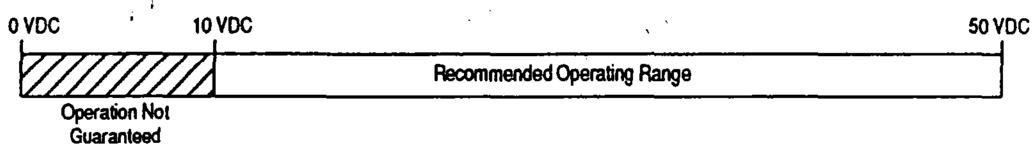


Output Circuit Diagram



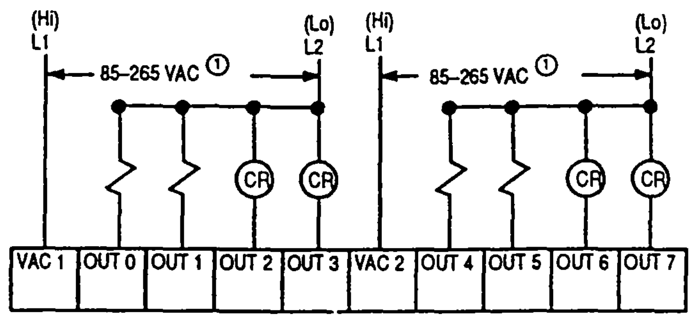
Operating Voltage Range

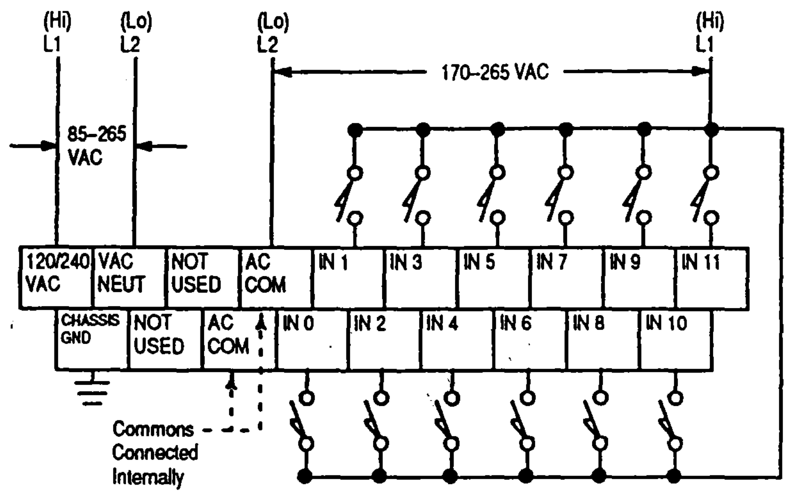
(Voltage is applied between +VDC and DC common.)



Catalog Number 1747–L20P (12) 240 VAC Inputs & (8) Triac Outputs

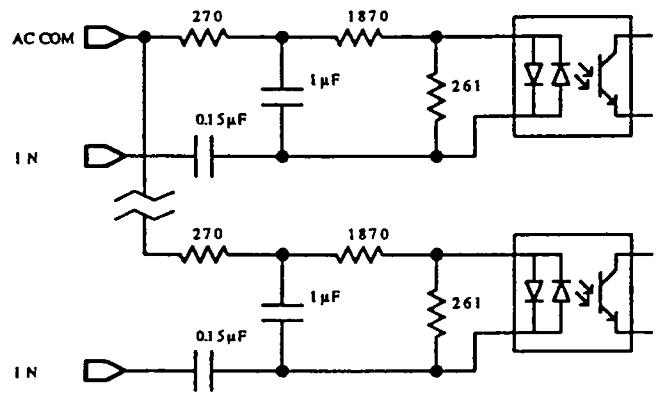
Wiring Diagram





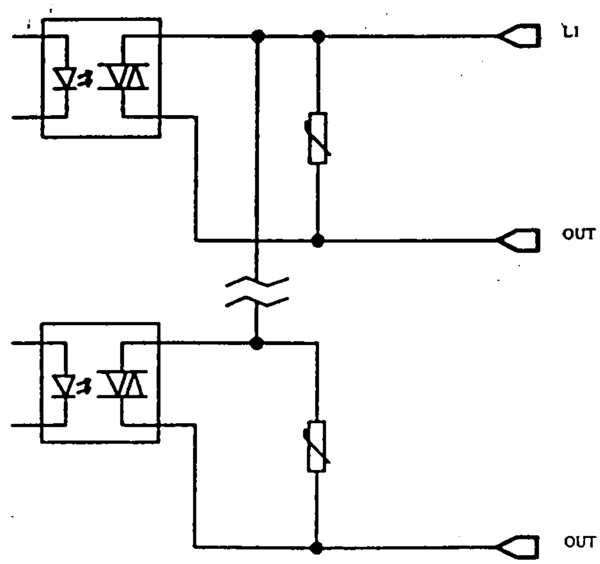
① *These outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

Input Circuit Diagram

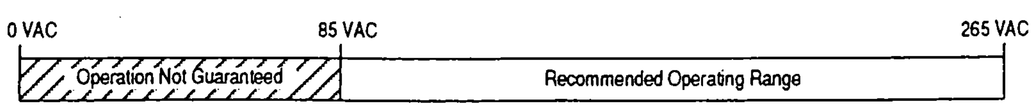


On/Off State Voltage Ranges

Output Circuit Diagram



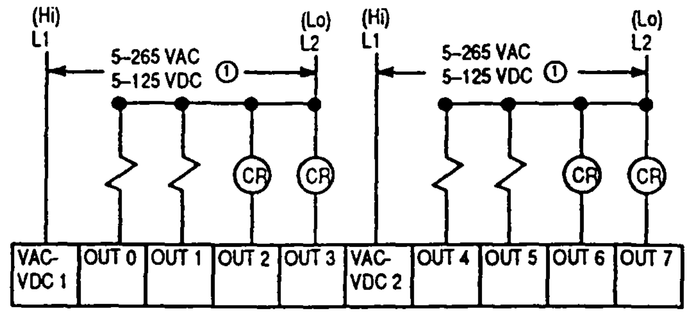
Operating Voltage Range

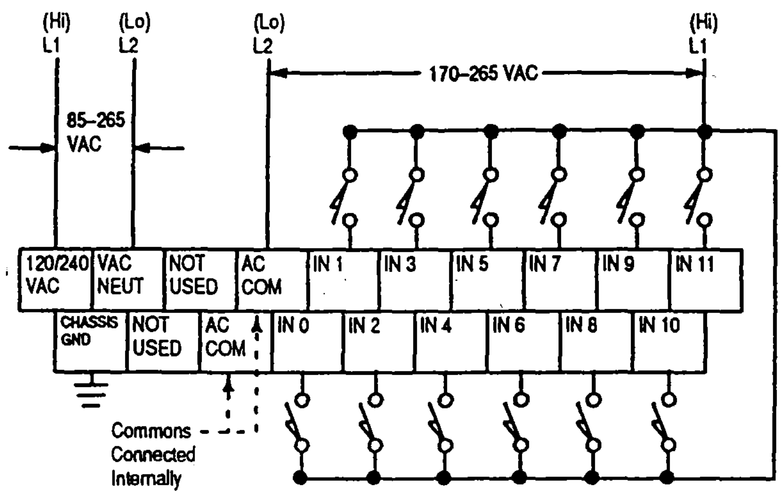


Important: If you measure the voltage at an output terminal that is not connected to a load or is connected to a high–impedance load, you may measure as much as 100 VAC even though the output is off.

Catalog Number 1747–L20R (12) 240 VAC Inputs & (8) Relay Outputs

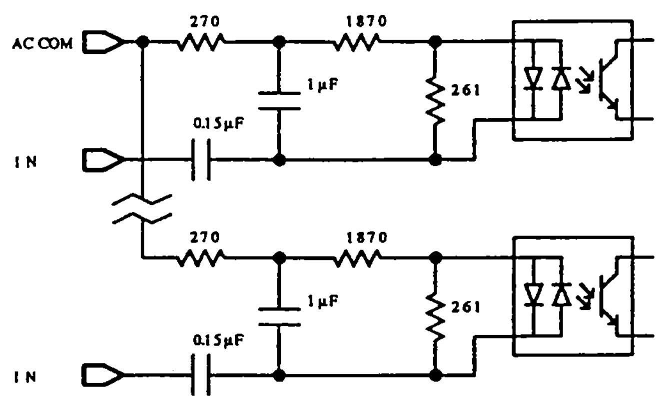
Wiring Diagram



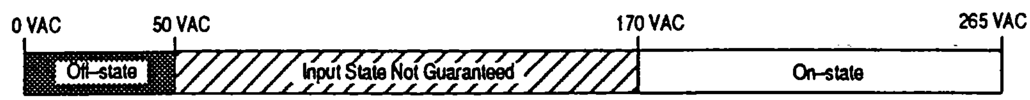


① *These outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

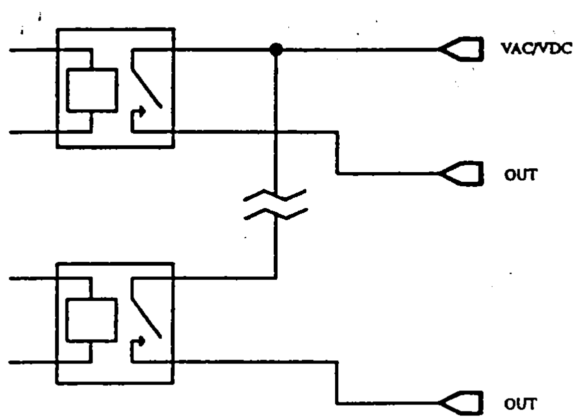
Input Circuit Diagram



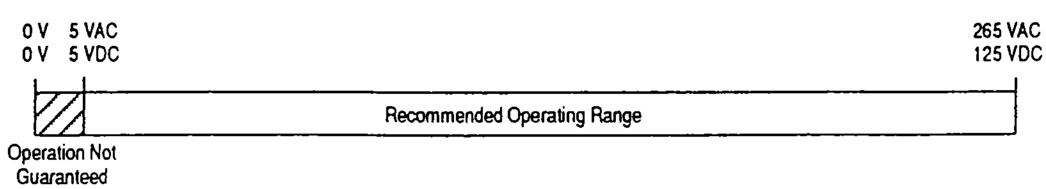
On/Off State Voltage Ranges



Output Circuit Diagram

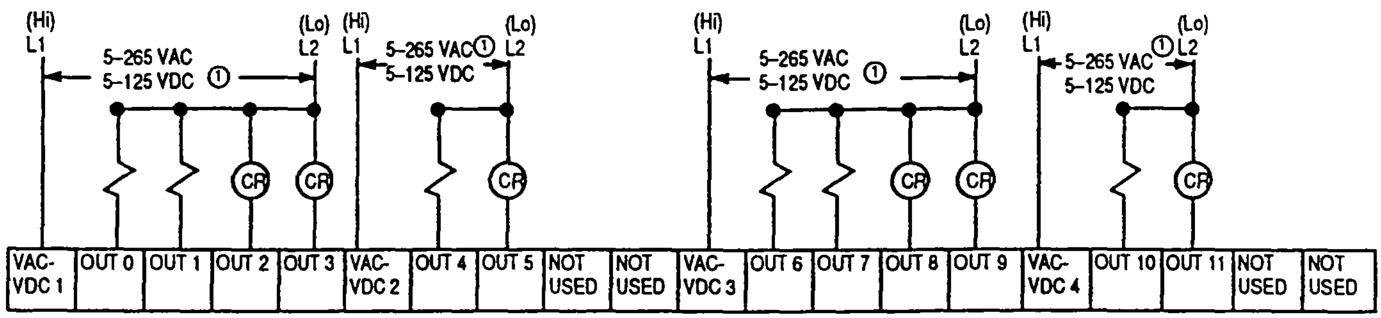


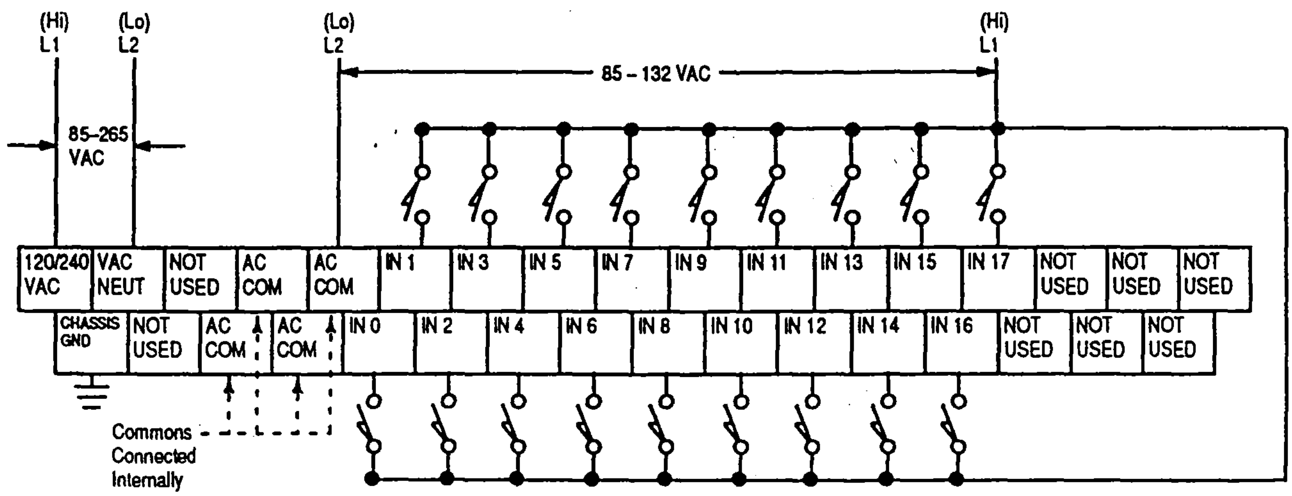
Operating Voltage Range



Catalog Number 1747–L30A (18) 120 VAC Inputs & (12) Relay Outputs

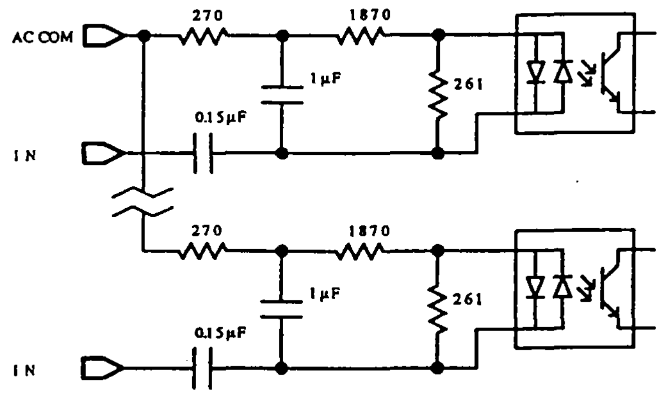
Wiring Diagram



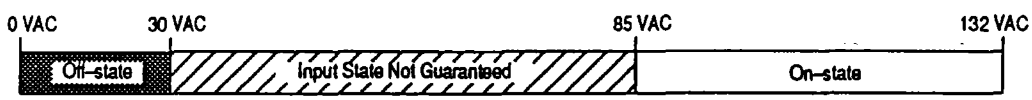


① *These outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

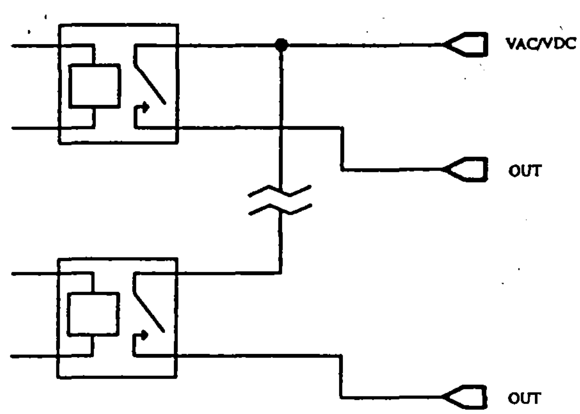
Input Circuit Diagram



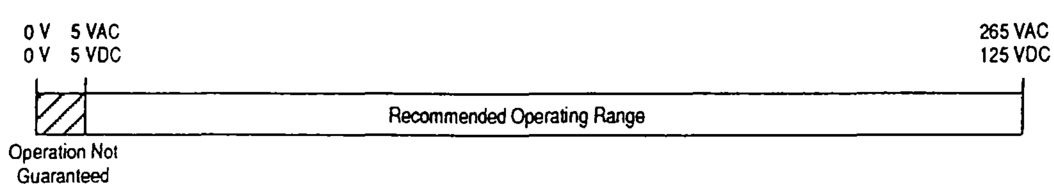
On/Off State Voltage Ranges



Output Circuit Diagram

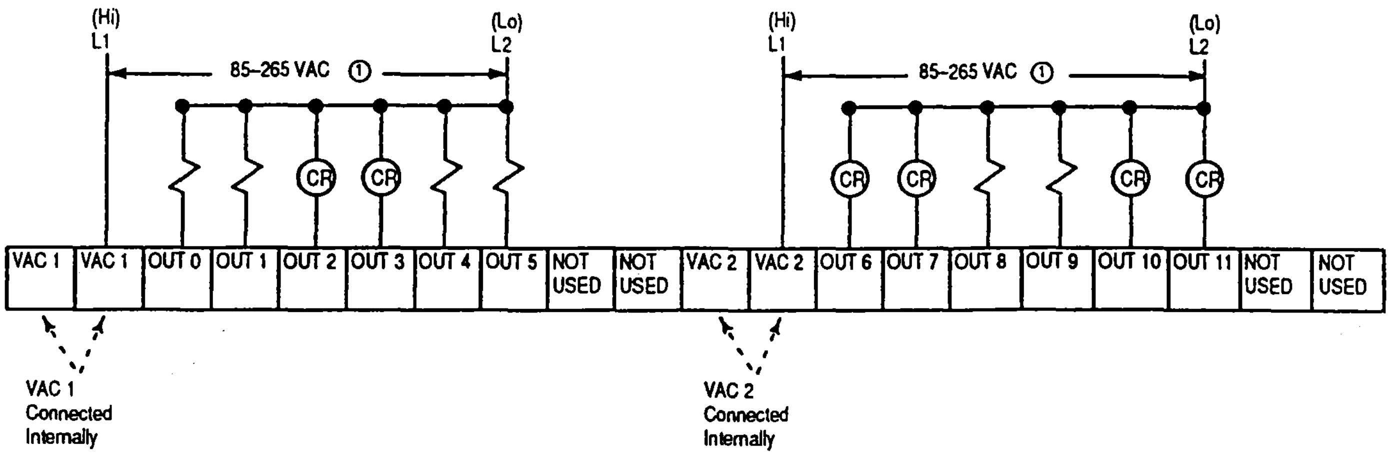


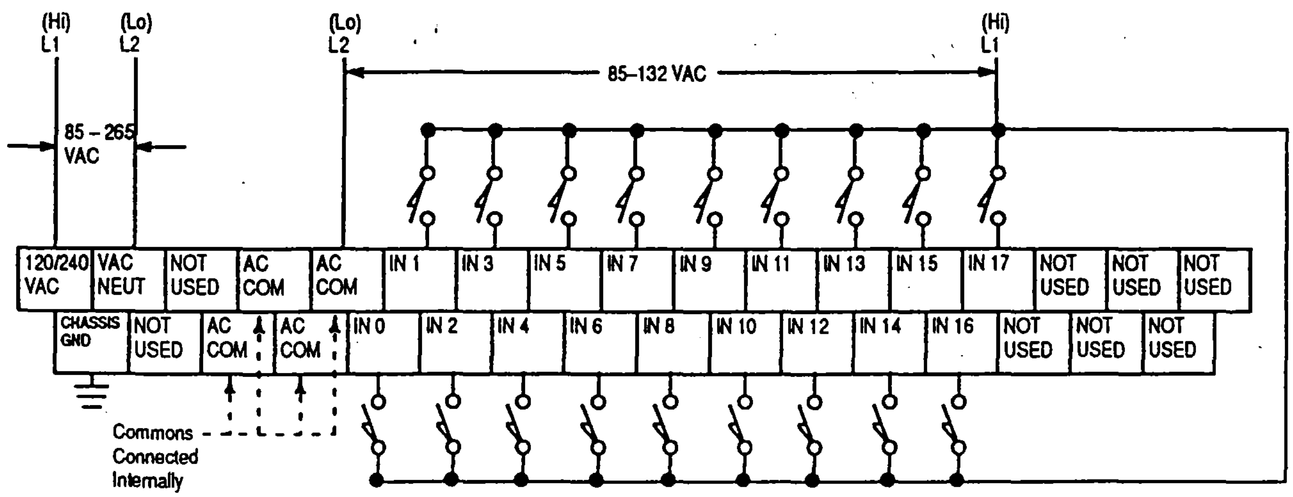
Operating Voltage Range



Catalog Number 1747–L30B (18) 120 Vac Inputs & (12) Triac Outputs

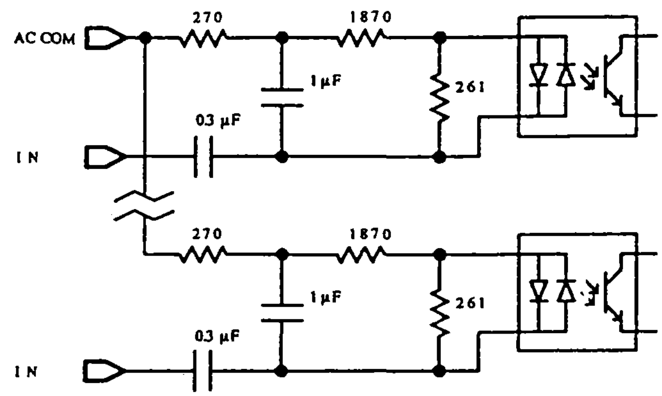
Wiring Diagram



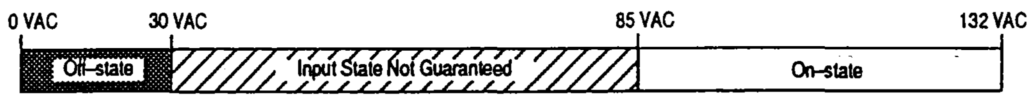


① *These outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

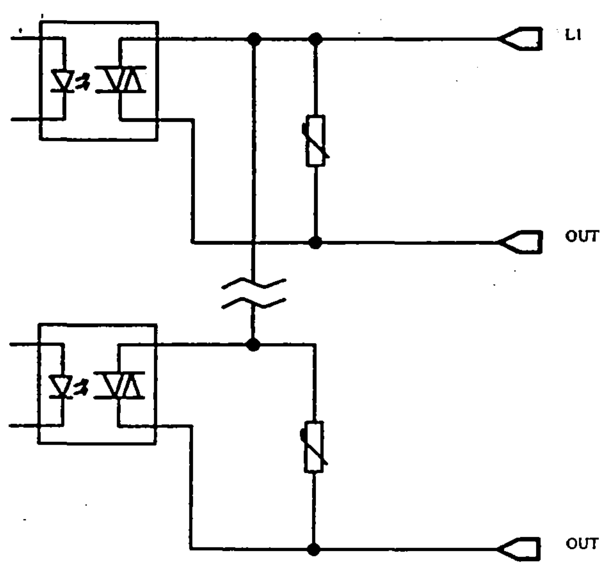
Input Circuit Diagram



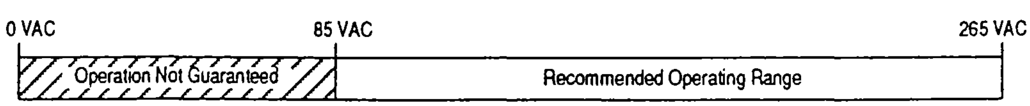
On/Off State Voltage Ranges



Output Circuit Diagram



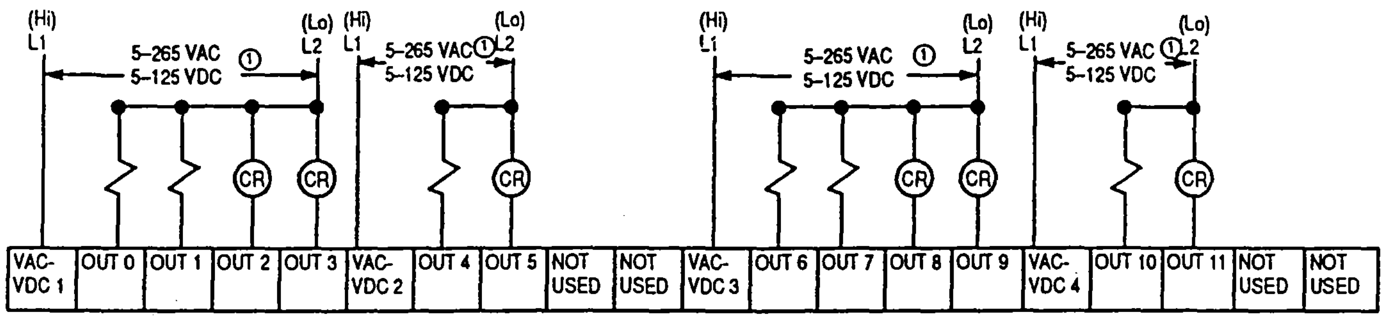
Operating Voltage Range

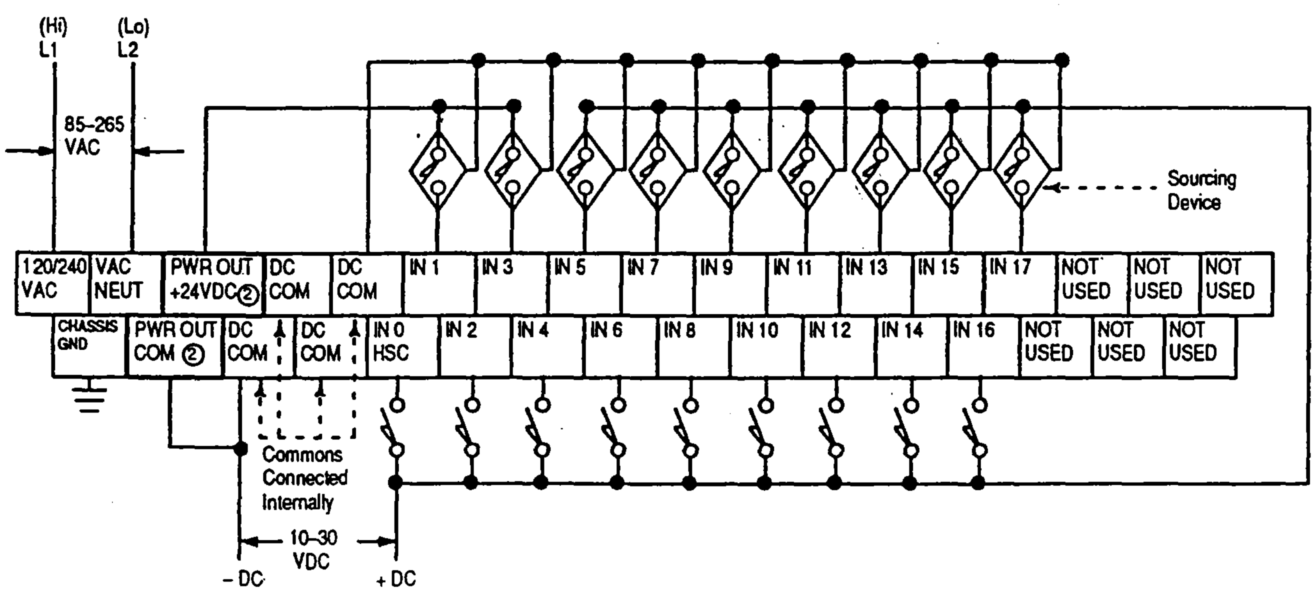


Important: If you measure the voltage at an output terminal that is not connected to a load or is connected to a high–impedance load, you may measure as much as 100 VAC even though the output is off.

Catalog Number 1747–L30C (18) 24 VDC Sinking Inputs, High–Speed Counter Input & (12) Relay Outputs

Wiring Diagram

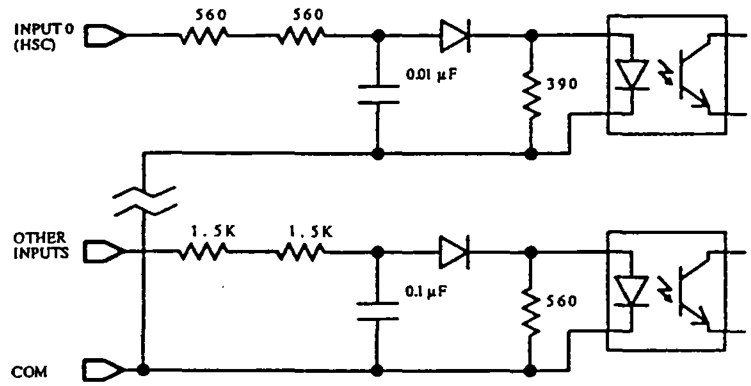




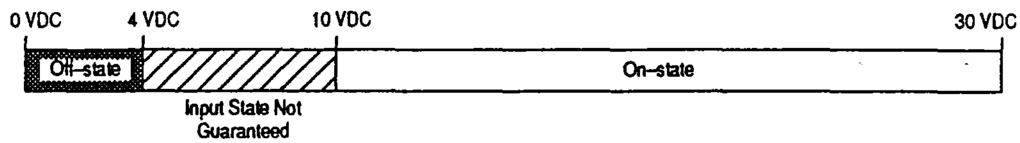
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

② *24 VDC, 200mA user power is available for sensors.*

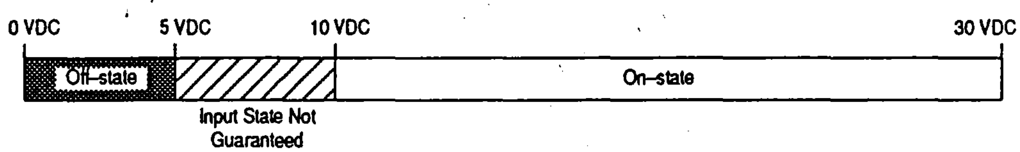
Input Circuit Diagram



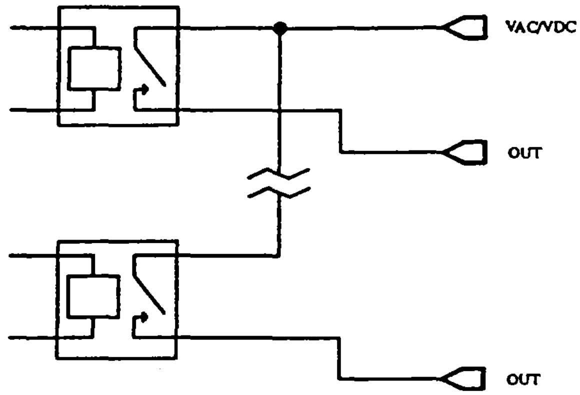
On/Off State Voltage Ranges – Input 0 (HSC)



On/Off State Voltage Ranges – All Other Inputs



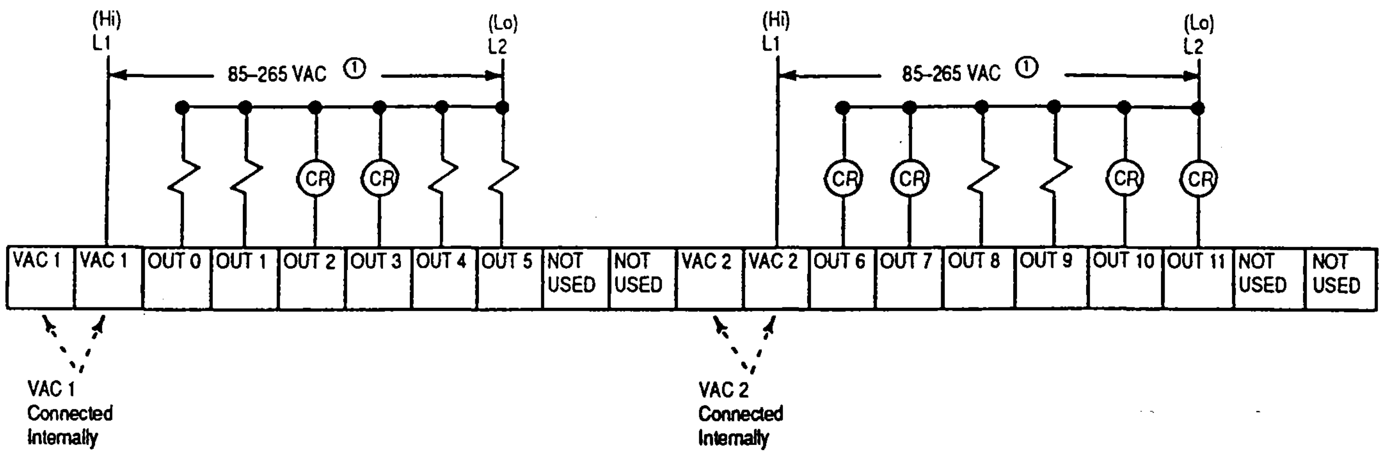
Output Circuit Diagram

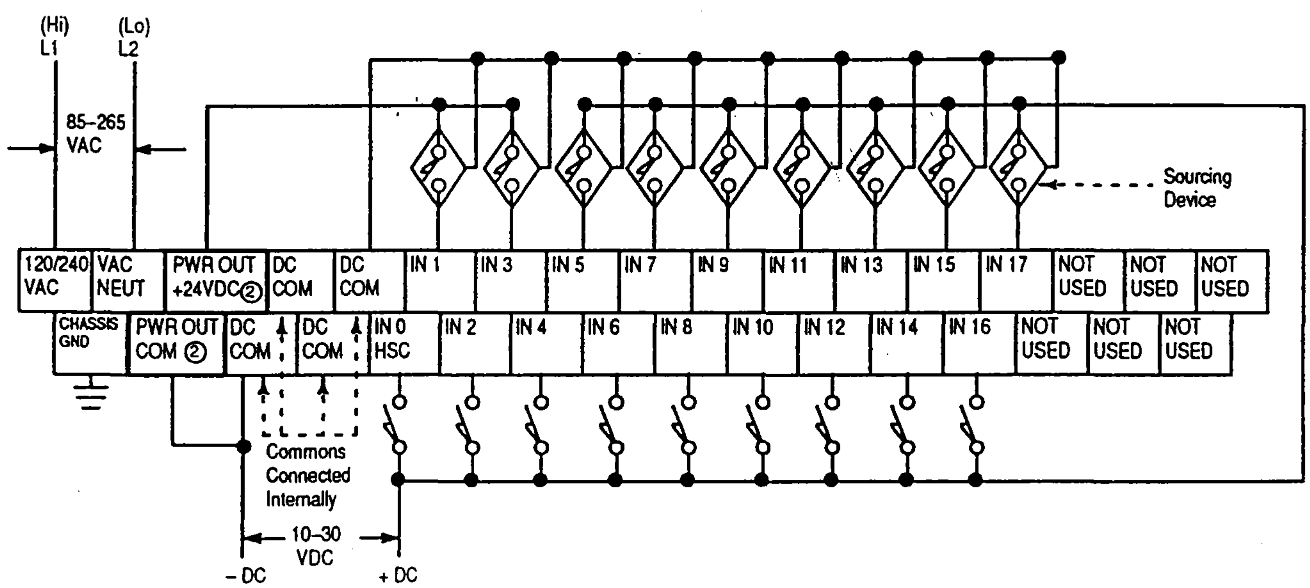


Operating Voltage Range

Catalog Number 1747–L30D (18) 24 VDC Sinking Inputs, High–Speed Counter Input & (12) Triac Outputs

Wiring Diagram

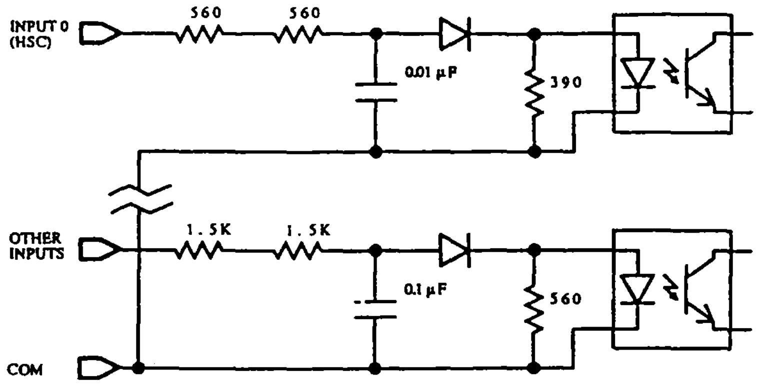




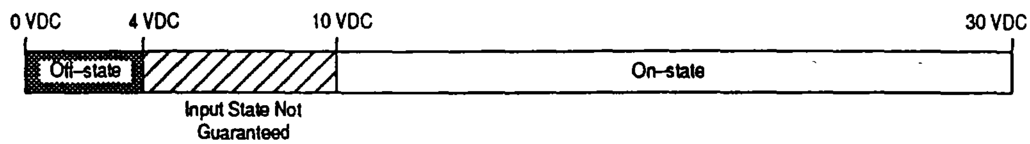
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

② *24 VDC, 200mA user power is available for sensors.*

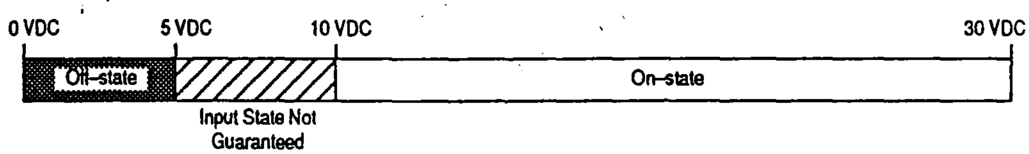
Input Circuit Diagram



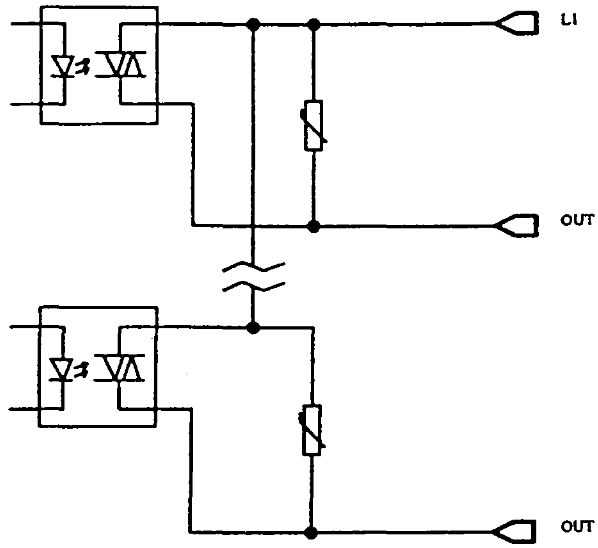
On/Off State Voltage Ranges – Input 0 (HSC)



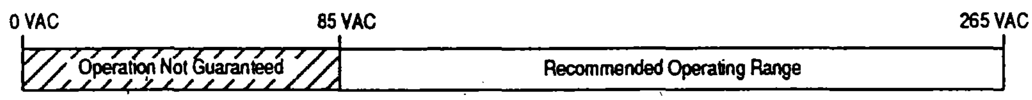
On/Off State Voltage Ranges – All Other Inputs



Output Circuit Diagram



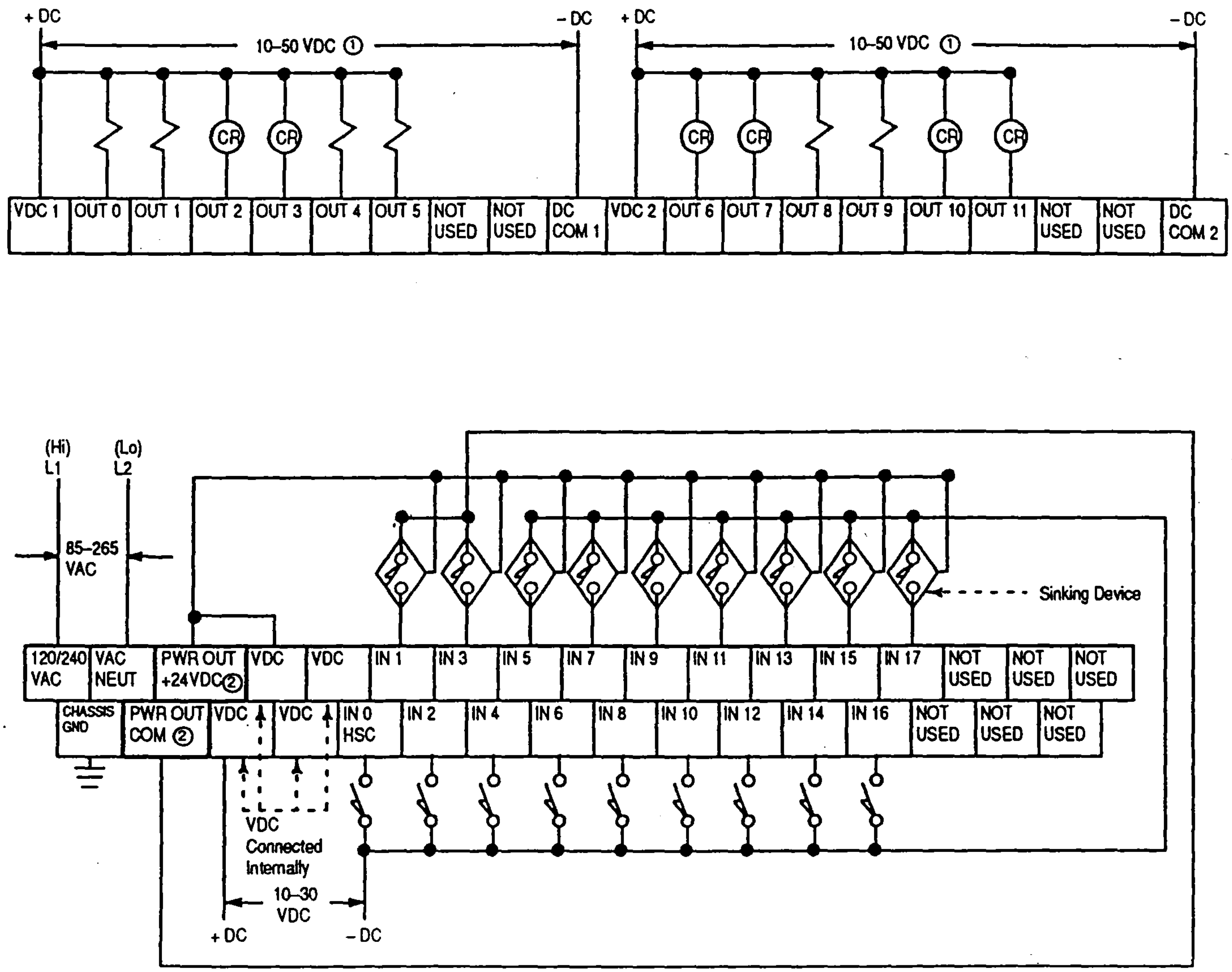
Operating Voltage Range



Important: If you measure the voltage at an output terminal that is not connected to a load or is connected to a high–impedance load, you may measure as much as 100 VAC even though the output is off.

Catalog Number 1747–L30L (18) 24 VDC Sourcing Inputs, High–Speed Counter Input & (12) Transistor Sinking Outputs

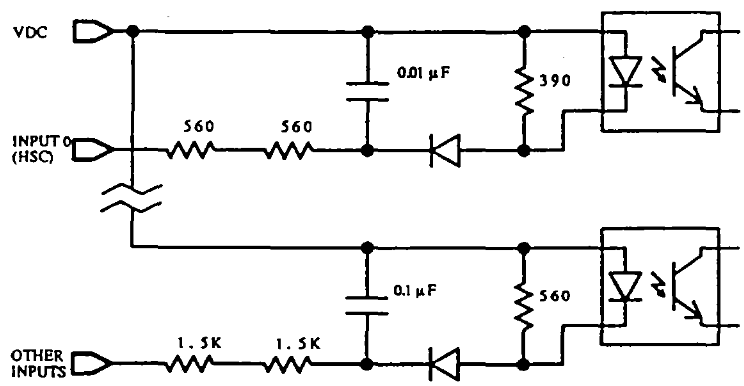
Wiring Diagram



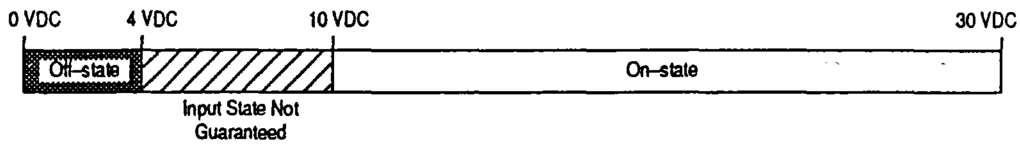
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

② *24 VDC, 200mA user power is available for sensors.*

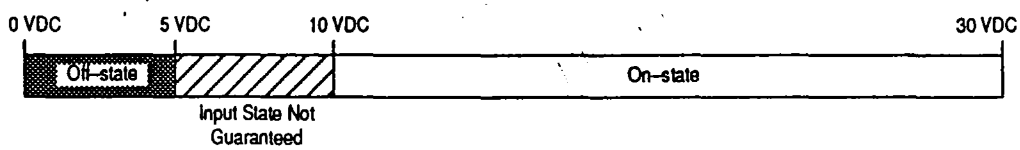
Input Circuit Diagram



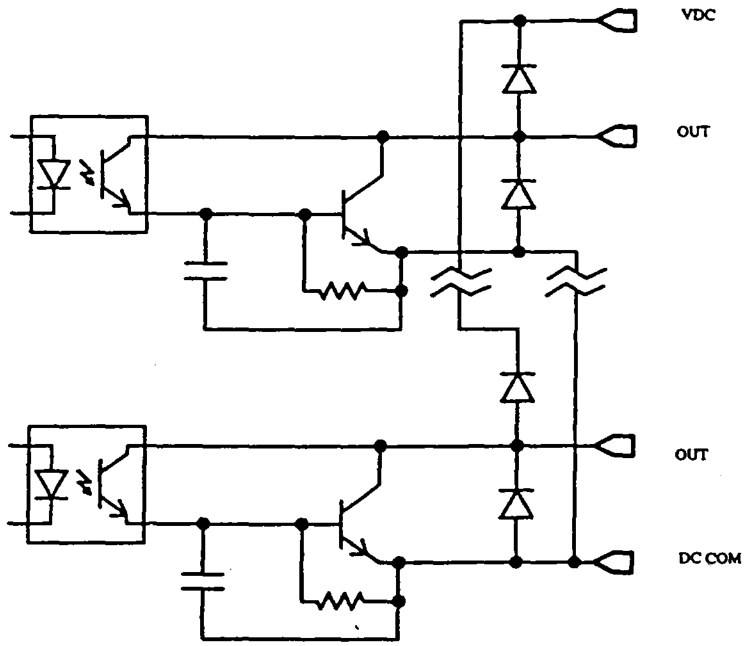
On/Off State Voltage Ranges – Input 0 (HSC)



On/Off State Voltage Ranges – All Other Inputs

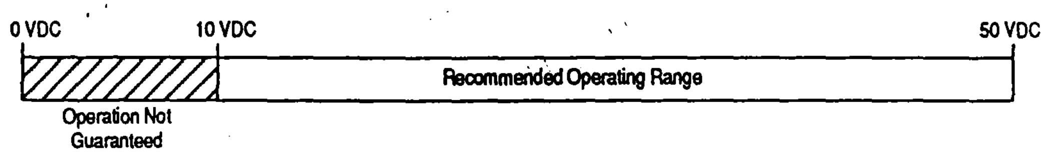


Output Circuit Diagram



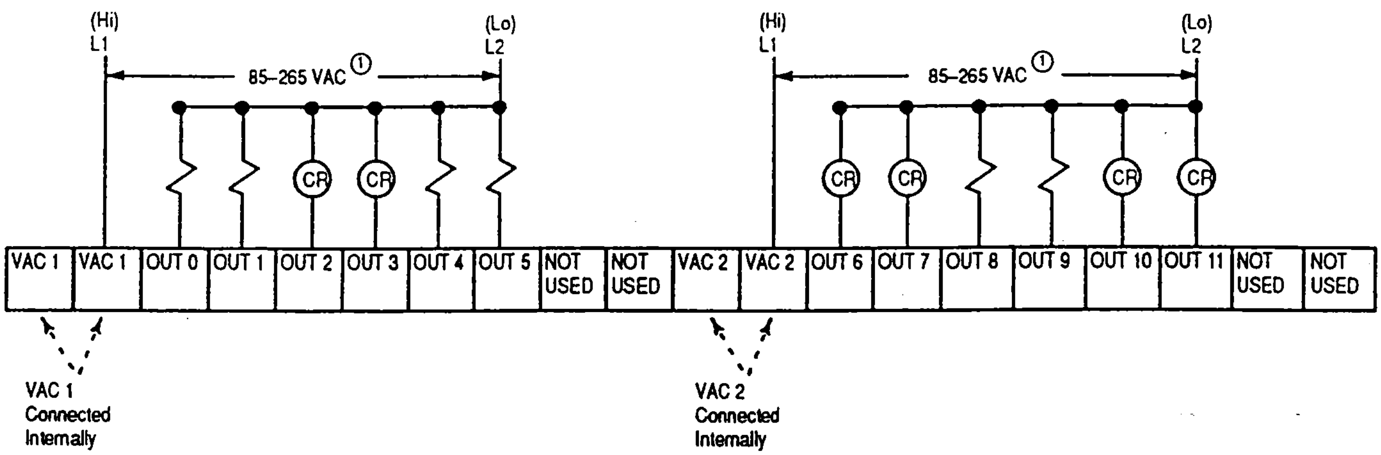
Operating Voltage Range

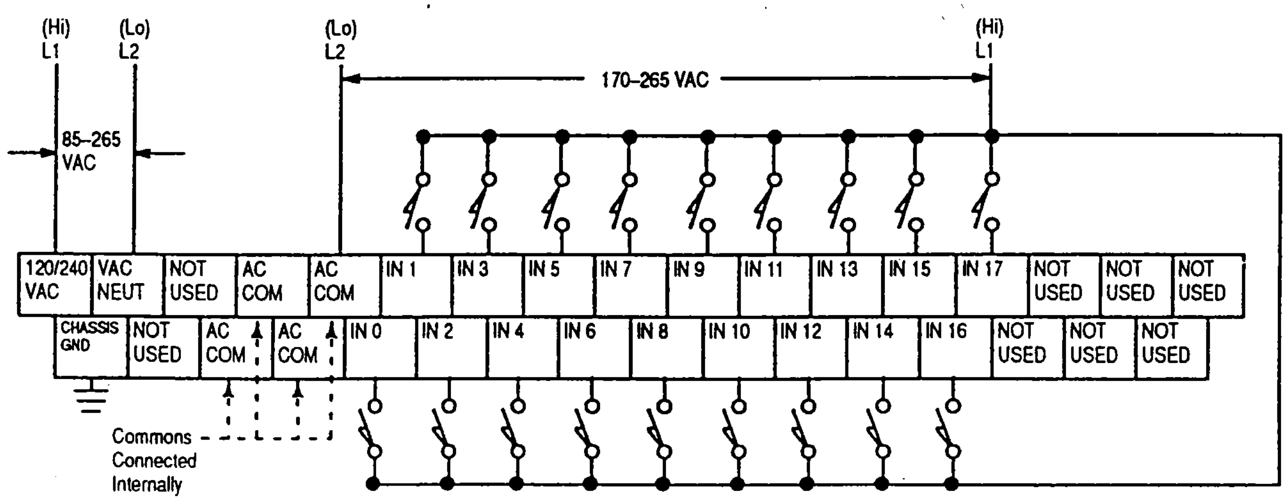
(Voltage is applied between +VDC and DC common.)



Catalog Number 1747–L30P (18) 240 VAC Inputs & (12) Triac Outputs

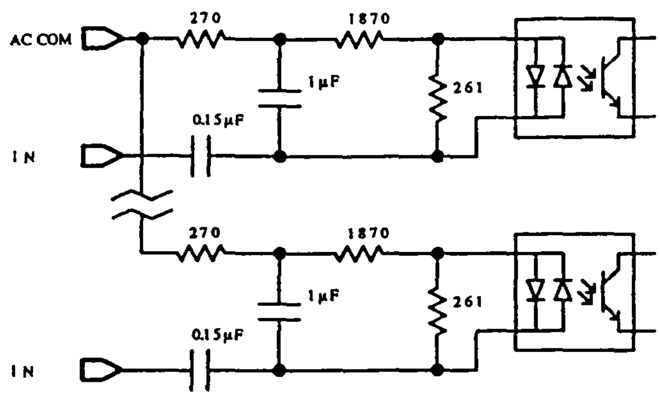
Wiring Diagram





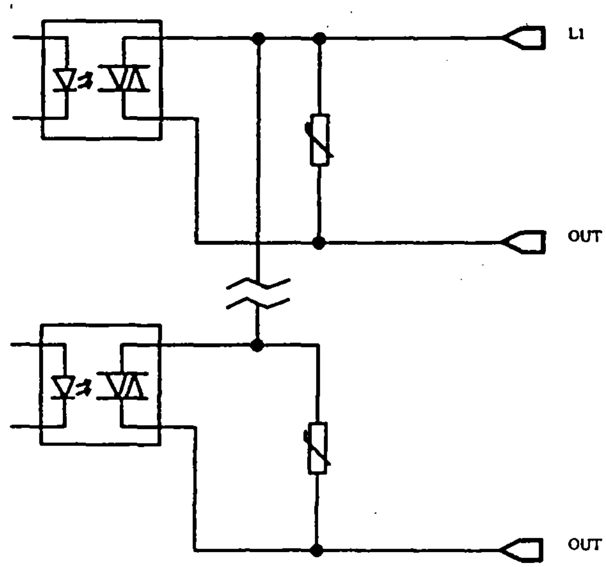
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

Input Circuit Diagram

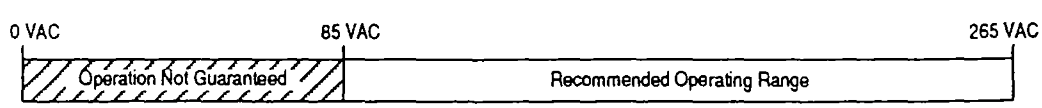


On/Off State Voltage Ranges

Output Circuit Diagram



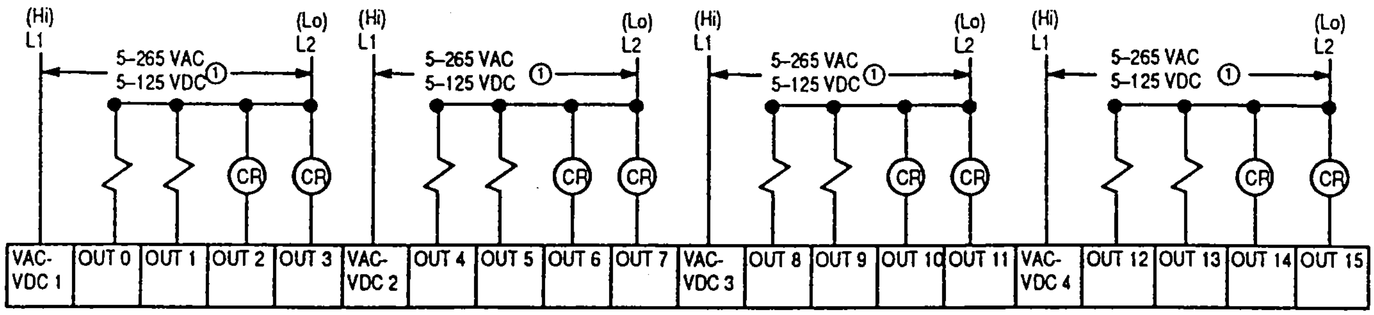
Operating Voltage Range

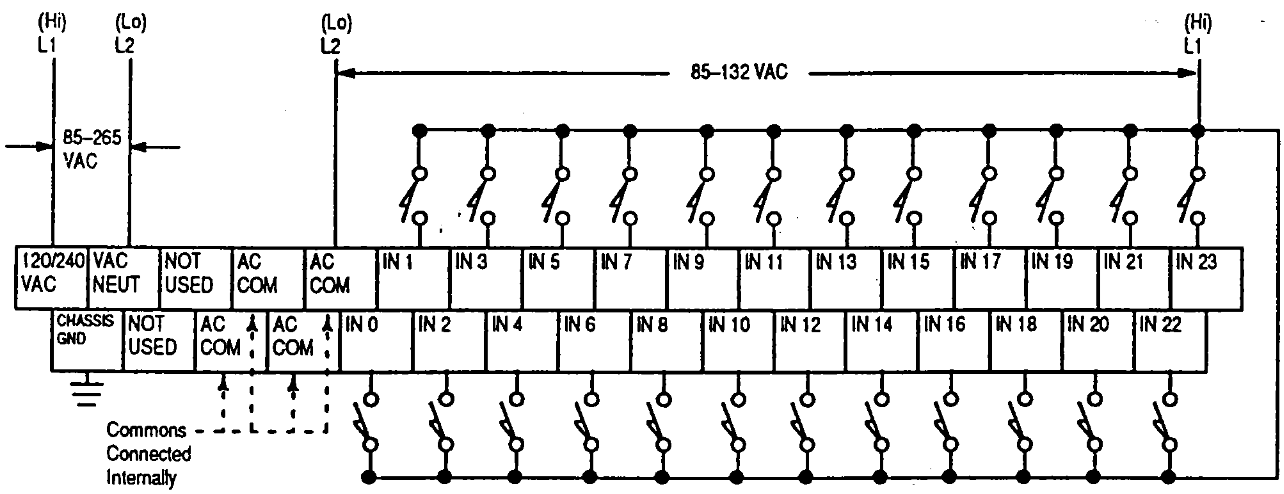


Important: If you measure the voltage at an output terminal that is not connected to a load or is connected to a high–impedance load, you may measure as much as 100 VAC even though the output is off.

Catalog Number 1747–L40A (24) 120 VAC Inputs & (16) Relay Outputs

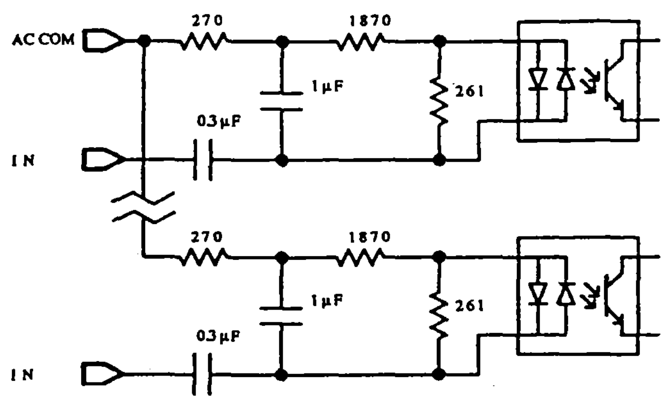
Wiring Diagram





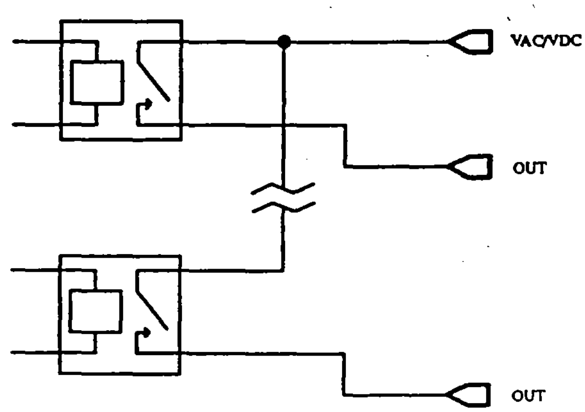
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

Input Circuit Diagram

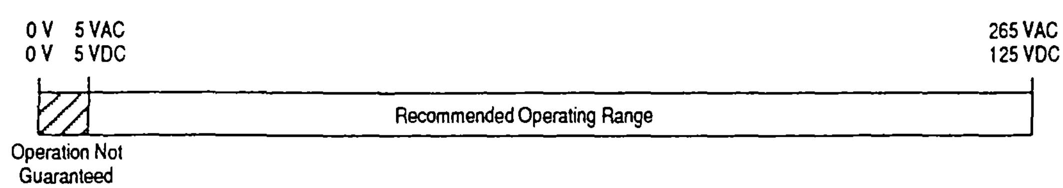


On/Off State Voltage Ranges

Output Circuit Diagram

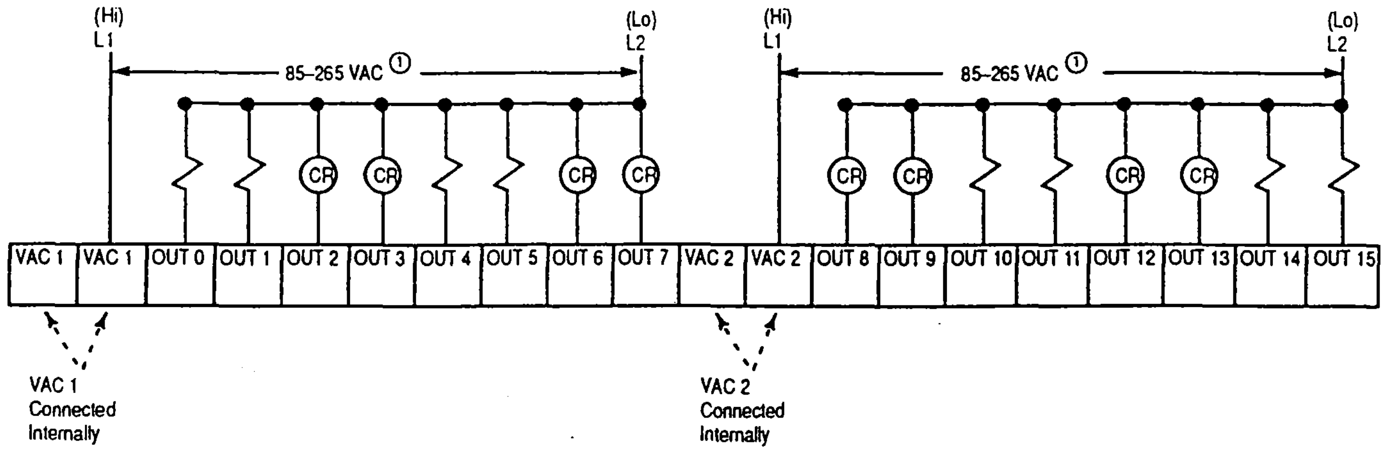


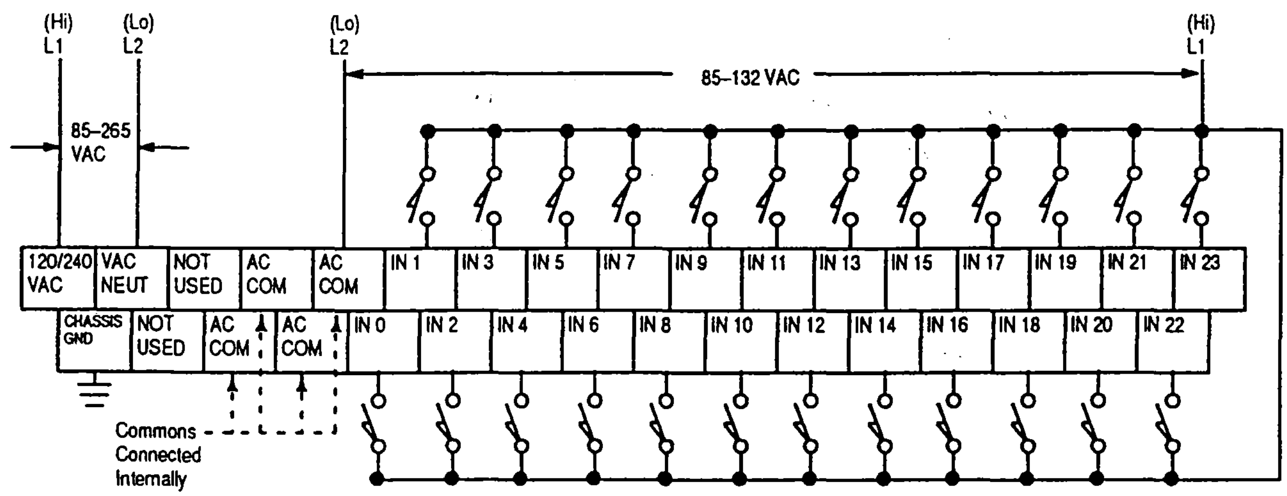
Operating Voltage Range



Catalog Number 1747–L40B (24) 120 VAC Inputs & (16) Triac Outputs

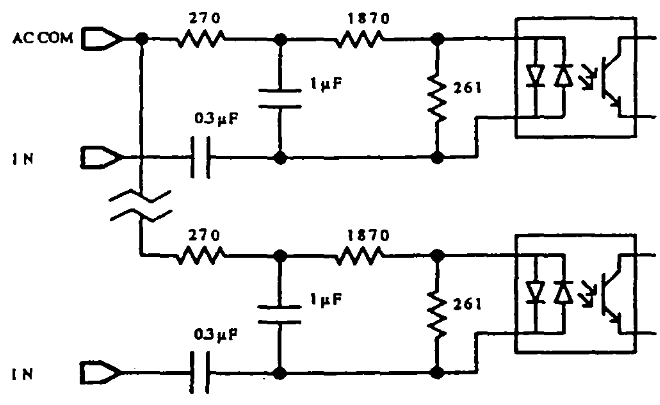
Wiring Diagram





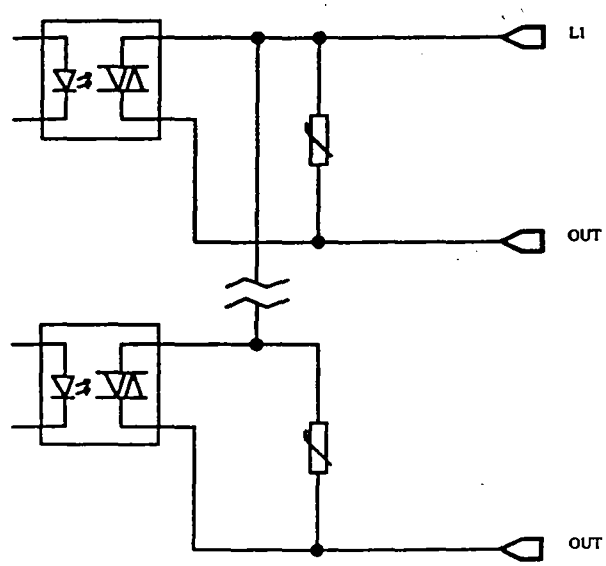
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

Input Circuit Diagram

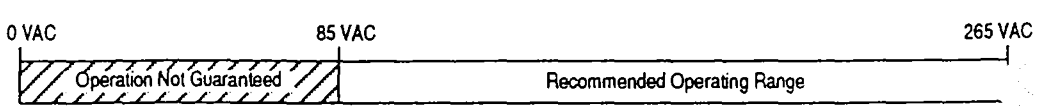


On/Off State Voltage Ranges

Output Circuit Diagram



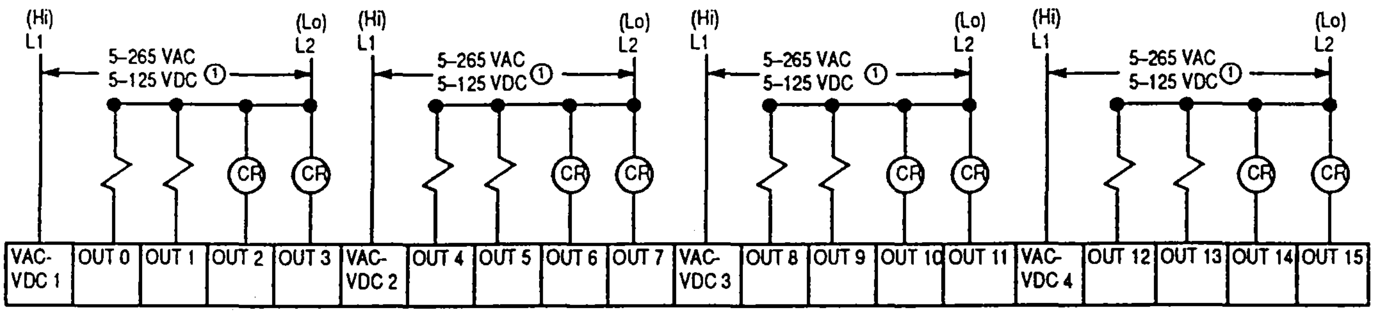
Operating Voltage Range

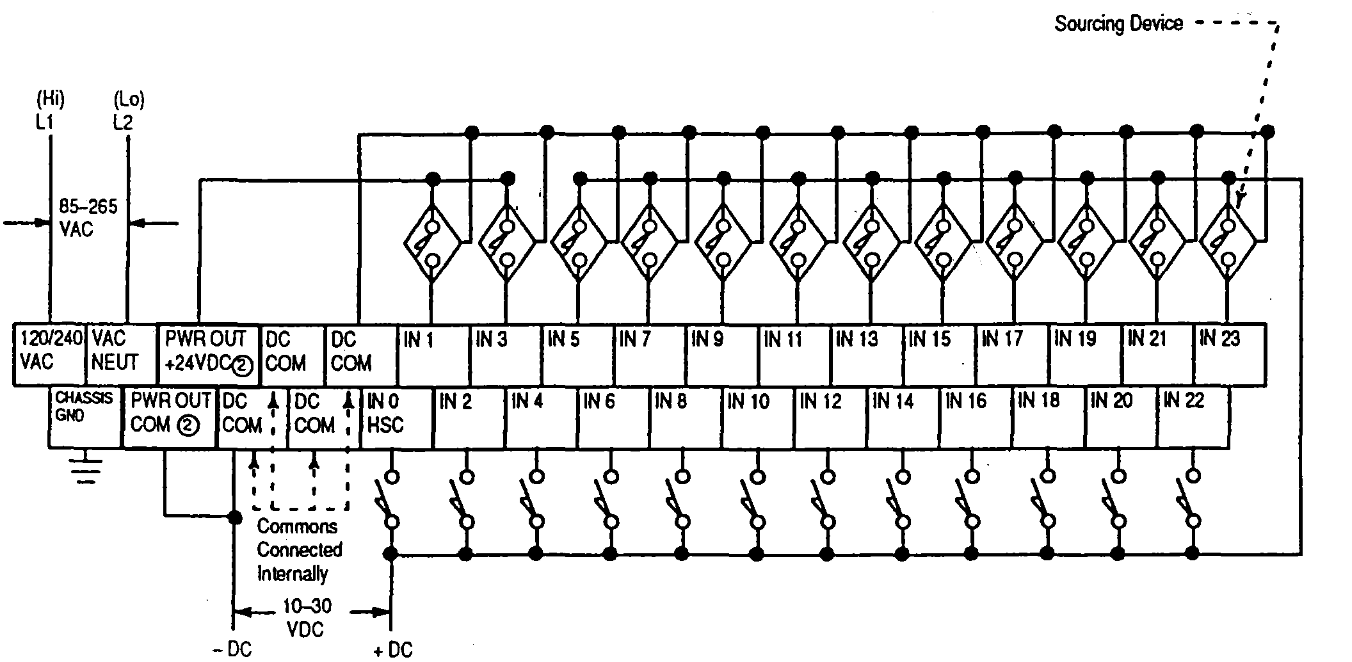


Important: If you measure the voltage at an output terminal that is not connected to a load or is connected to a high–impedance load, you may measure as much as 100 VAC even though the output is off.

Catalog Number 1747–L40C (24) 24 VDC Sinking Inputs, High–Speed Counter Input & (16) Relay Outputs

Wiring Diagram

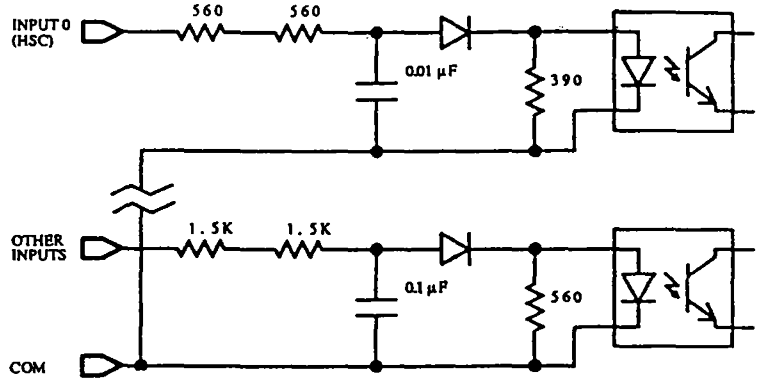




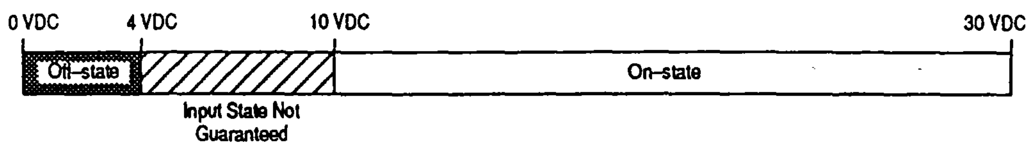
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

② *24 VDC, 200mA user power is available for sensors.*

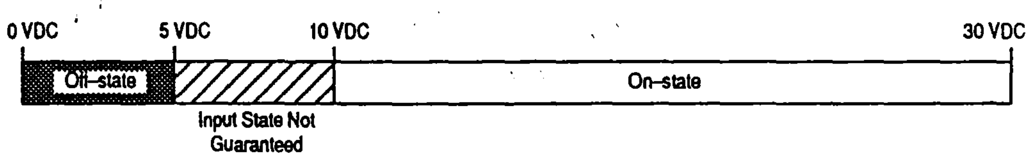
Input Circuit Diagram



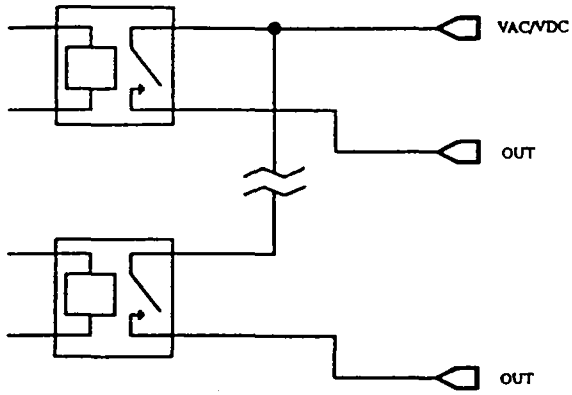
On/Off State Voltage Ranges – Input 0 (HSC)



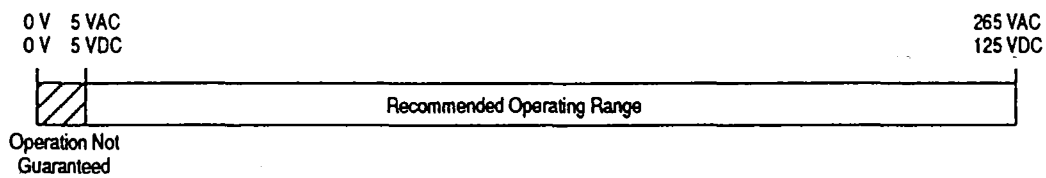
On/Off State Voltage Ranges – All Other Inputs



Output Circuit Diagram

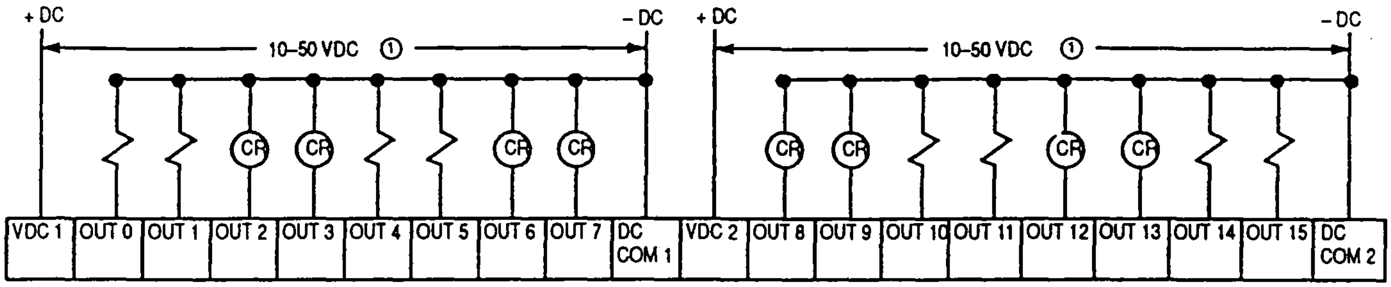


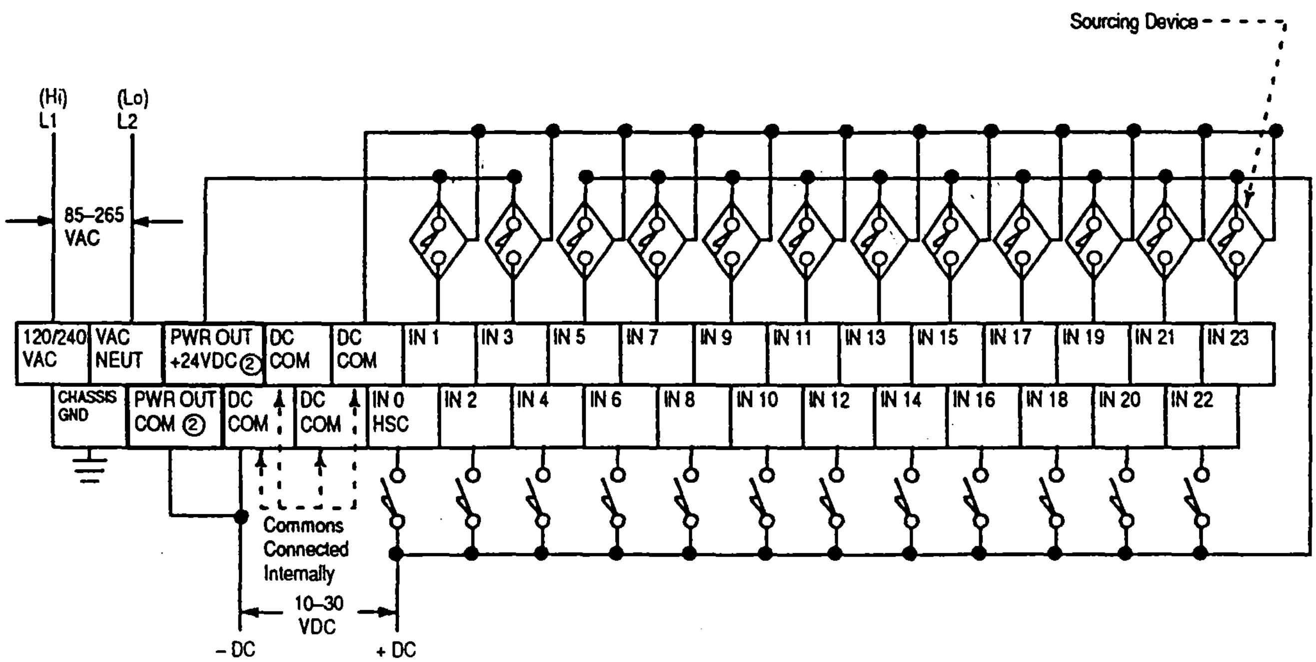
Operating Voltage Range



Catalog Number 1747–L40E (24) 24 VDC Sinking Inputs, High–Speed Counter Input & (16) Transistor Sourcing Outputs

Wiring Diagram

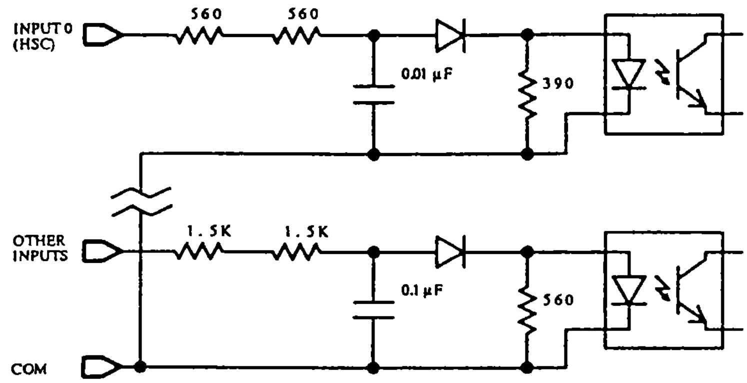




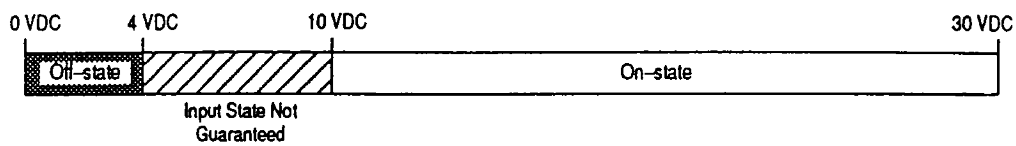
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

② *24 VDC, 200mA user power is available for sensors.*

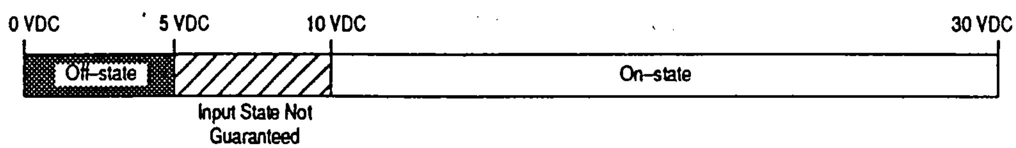
Input Circuit Diagram



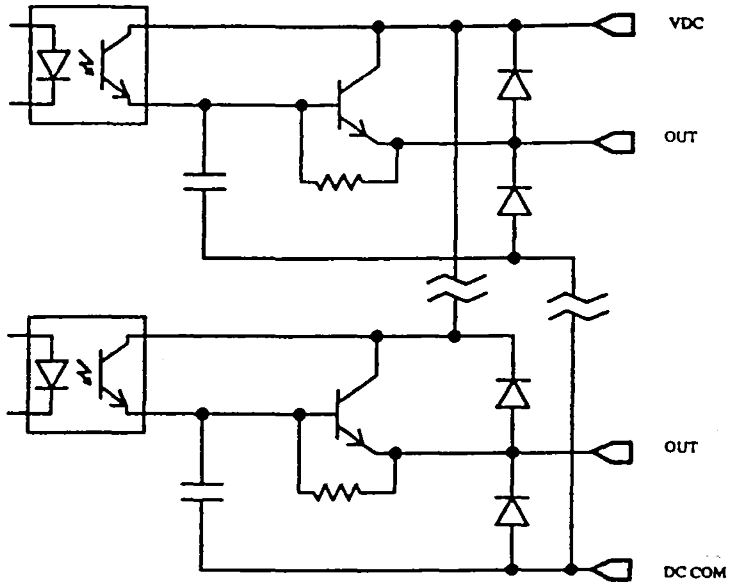
On/Off State Voltage Ranges – Input 0 (HSC)



On/Off State Voltage Ranges – All Other Inputs

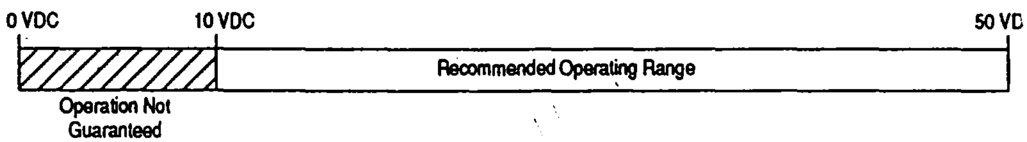


Output Circuit Diagram



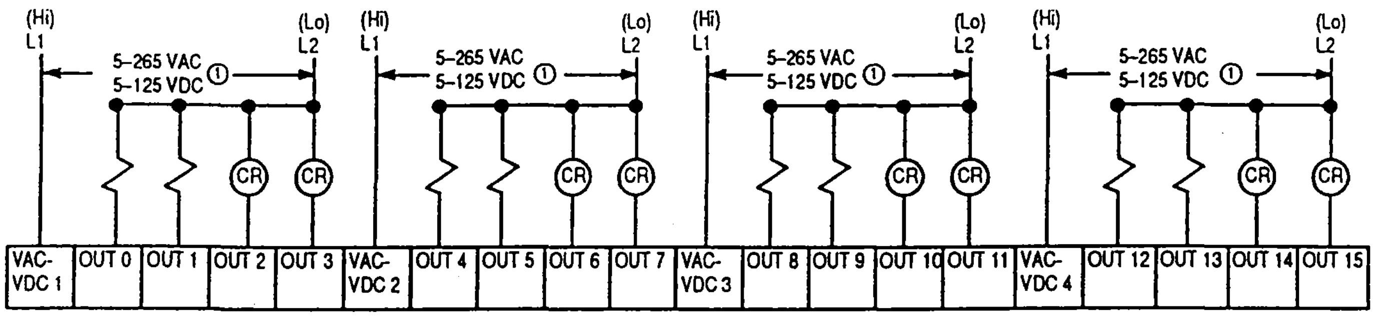
Operating Voltage Range

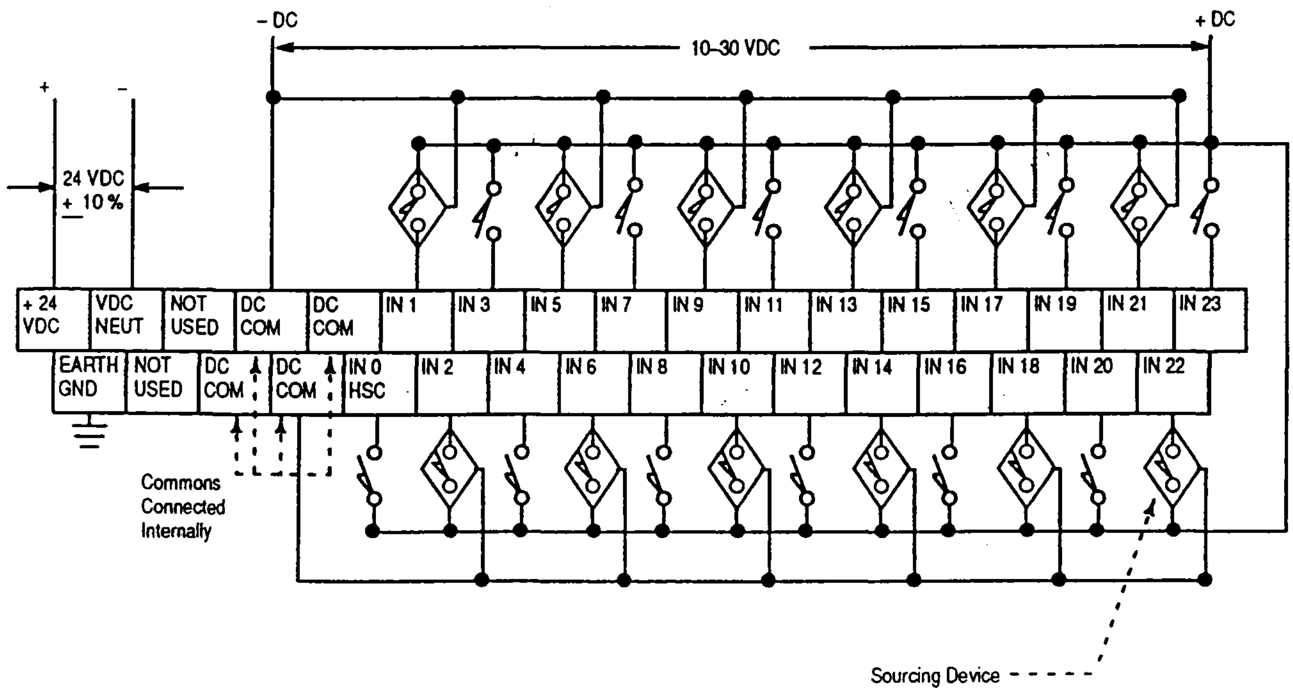
(Voltage is applied between +VDC and DC common.)



Catalog Number 1747–L40F (24) 24 VDC Sinking Inputs, High–Speed Counter Input & (16) Relay Outputs

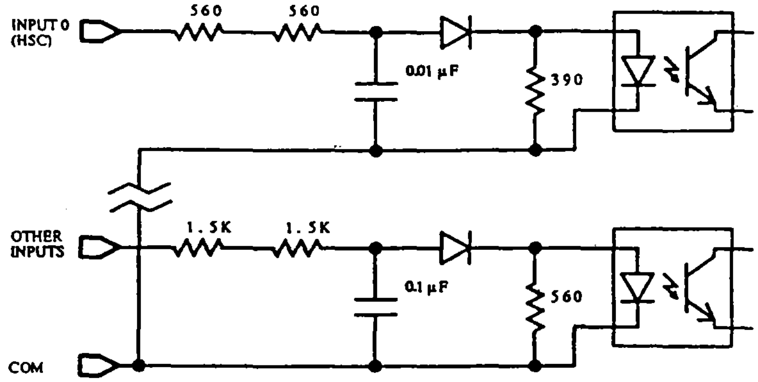
Wiring Diagram



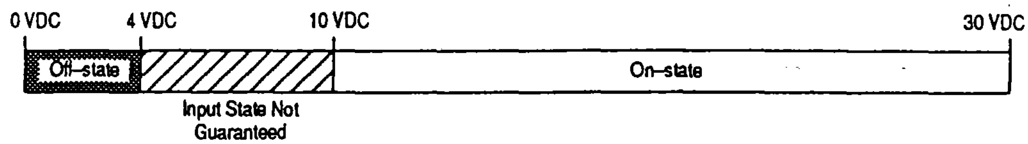


① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

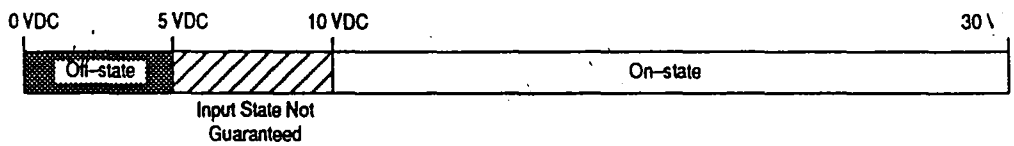
Input Circuit Diagram



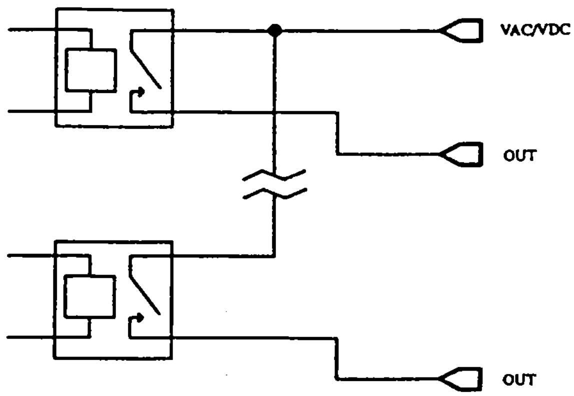
On/Off State Voltage Ranges – Input 0 (HSC)



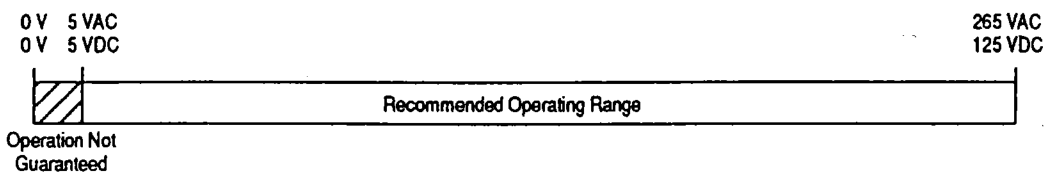
On/Off State Voltage Ranges – All Other Inputs



Output Circuit Diagram

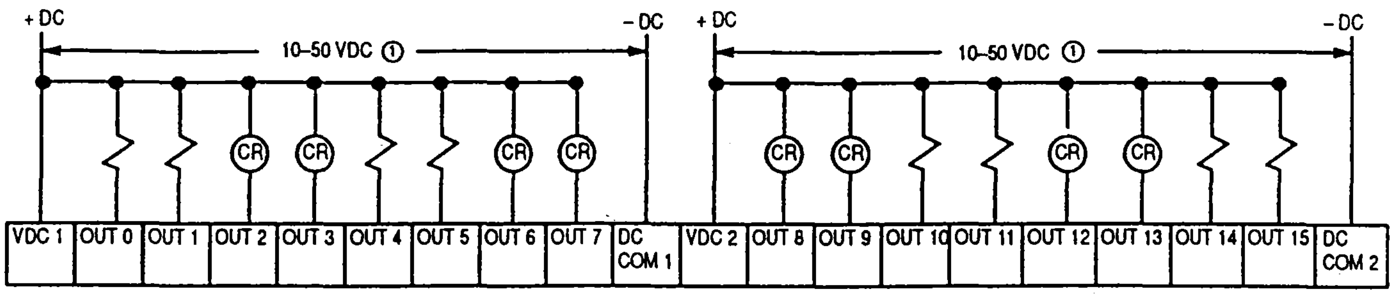


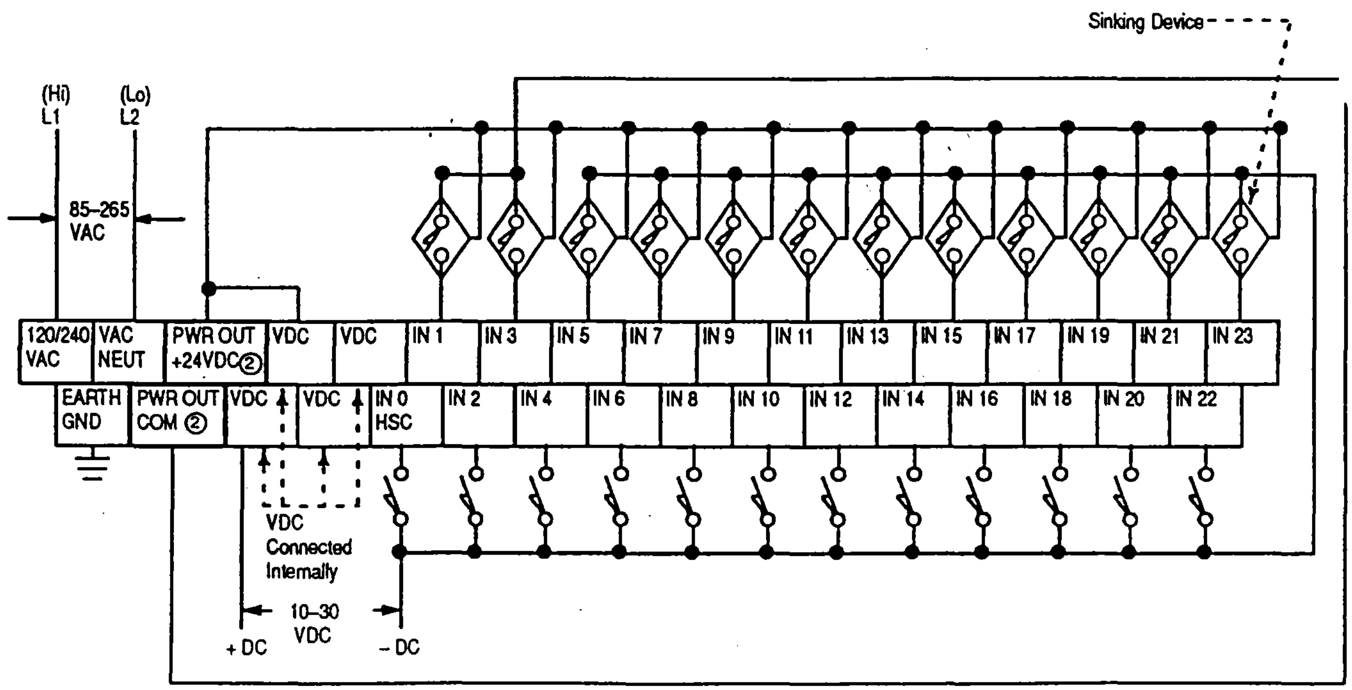
Operating Voltage Range



Catalog Number 1747–L40L (24) 24 VDC Sourcing Inputs, High–Speed Counter Input & (16) Transistor Sinking Outputs

Wiring Diagram

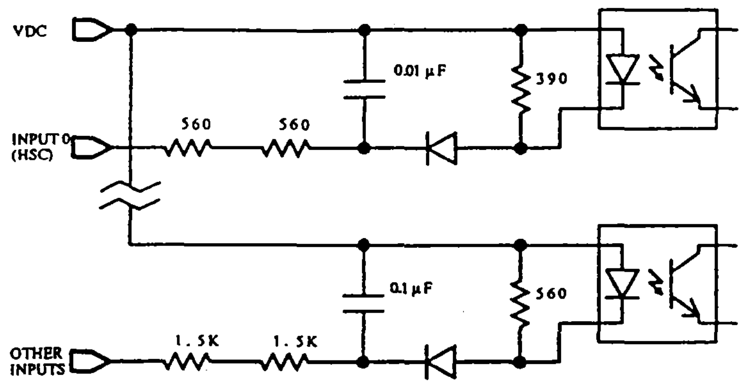




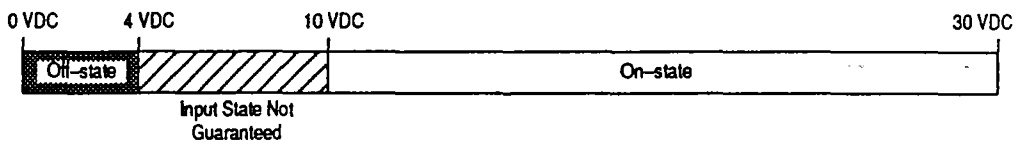
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

② *24 VDC, 200mA user power is available for sensors.*

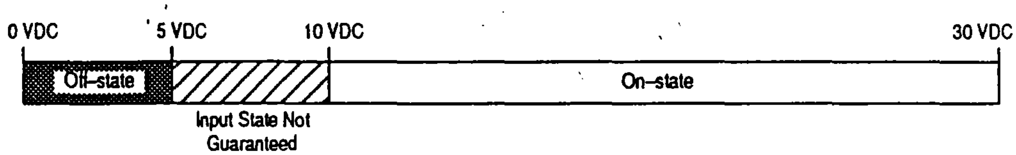
Input Circuit Diagram



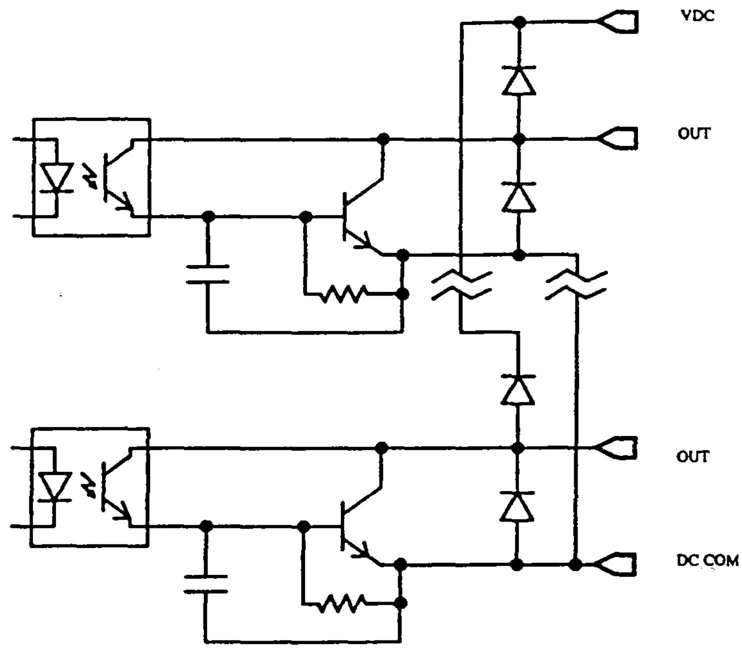
On/Off State Voltage Ranges – Input 0 (HSC)



On/Off State Voltage Ranges – All Other Inputs



Output Circuit Diagram

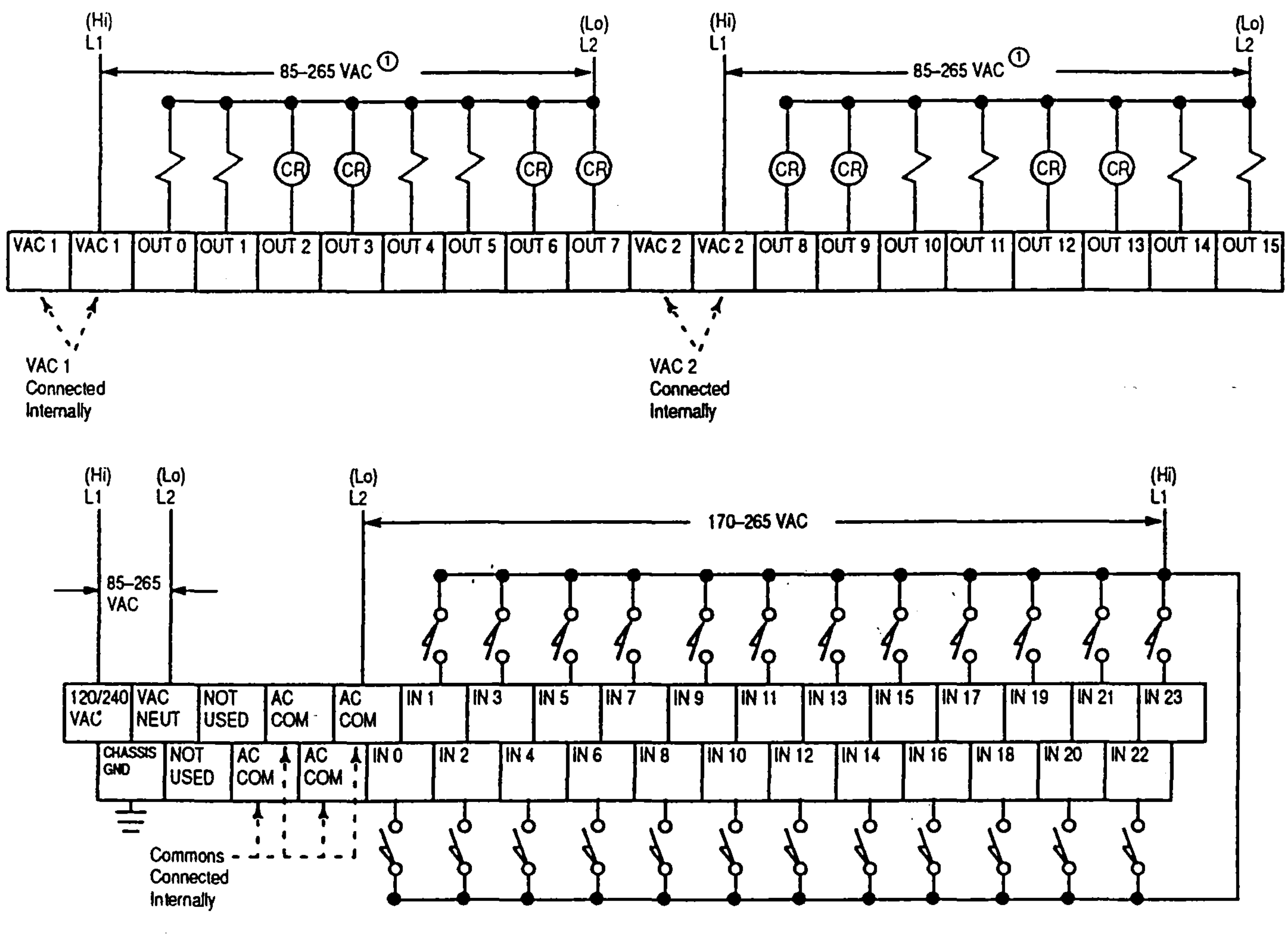


Operating Voltage Range

(Voltage is applied between +VDC and DC common.)

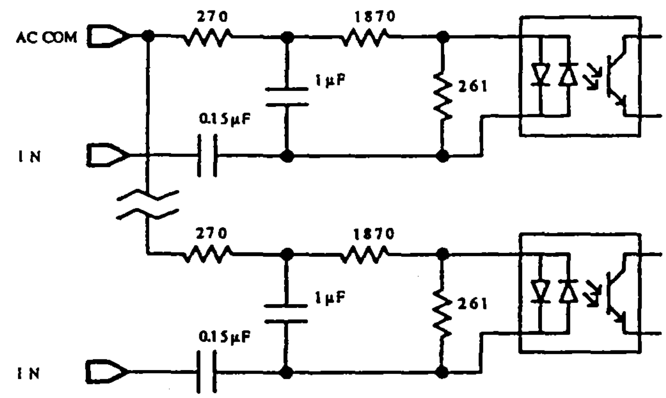
Catalog Number 1747–L40P (24) 240 VAC Inputs & (16) Triac Outputs

Wiring Diagram



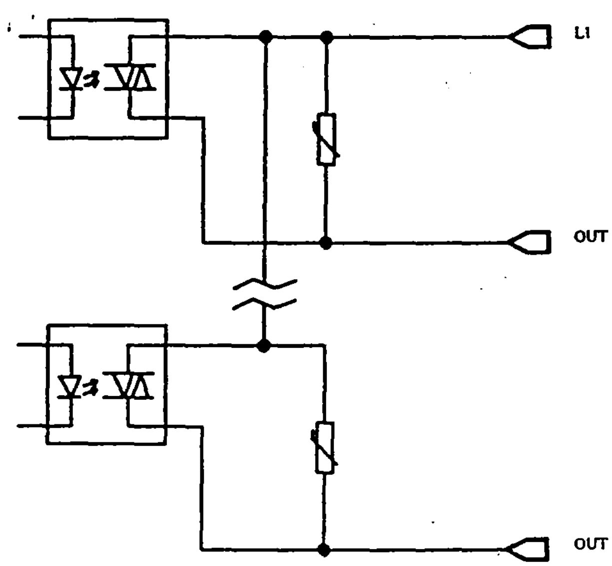
① *The outputs are isolated in groups as shown. Therefore, different voltages can be applied to each group as the specific application requires.*

Input Circuit Diagram

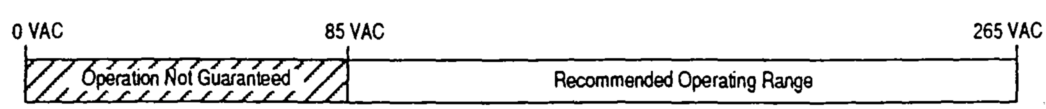


On/Off State Voltage Ranges

Output Circuit Diagram



Operating Voltage Range



Important: If you measure the voltage at an output terminal that is not connected to a load or is connected to a high–impedance load, you may measure as much as 100 VAC even though the output is off.

Glossary

Auto Answer — The type of modem that has self-contained timeouts and tests. They can answer and hang the phone up automatically.

Backplane Current Draw — The amount of current the module requires from the backplane. The sum of the backplane current draw for all modules in a chassis is used to select the appropriate chassis power supply.

Baud Rate — The speed of communication between devices on a network. All devices must communicate at the same baud rate. For example, the DH–485 network devices default to 19,200 baud.

Calculated Watts — The amount of heat generated by those points energized on an I/O module.

Channel — Communication port on a module.

Chassis — A hardware assembly that houses devices such as I/O modules, adapter modules, processor modules, and power supplies.

Continuous Current Per Module — The maximum current for each module. The sum of the output current for each point should not exceed this value.

Continuous Current Per Point — The maximum current each output is designed to continuously supply to a load.

CPU — Central Processing Unit or processor.

DF1 protocol — A peer–to–peer link–layer protocol that combines features of ANSI X3.28–1976 specification subcategories D1 (data transparency) and F1 (two–way simultaneous transmission with embedded responses).

Direct Connect — A type of modem that is connected to a dedicated, leased phone line and is active at all times.

DH–485 Network — The DH–485 network is a collection of devices connected to the communication cable allowing information exchange. A communication network based on the EIA Standard for RS–485 using an Allen–Bradley proprietary protocol.

DTE Controlled Answer — type of modem that is unattended and is attached directly to the phone lines. The interface module or the 5/03 processor acts as the Data Terminal Equipment (DTE), which controls the modem via the DTR, DSR, and DCD signals. The module incorporates timeouts and tests to properly operate these types of modems.

DTR Dialing (5/03 only) — type of modem that lets you dial a number or end a call based on the status of the RS–232 DTR (Data Terminal Ready) signal. To program the modem initialization string and phone number into the internal memory of the modem, use a dumb terminal (or PC running terminal emulation software like Procomm, Window's Terminal, or PBASE). Once you have programmed the modem, activate the DTR signal to dial the number, or deactivate the DTR signal to end the call.

EEPROM — Electrically Erasable Programmable Read Only Memory module used to store, back up, or transfer SLC 500 programs. The SLC 500 can read and write to an EEPROM.

Flash EPROM — Flash Erasable Programmable Read Only Memory module. It combines the programming versatility of EEPROMs with the security precautions of UVPROMs. This means that you have the option of leaving your EPROM programs write protected or unprotected.

Full–duplex — A high performance protocol that allows simultaneous two–way data transmission. For point–to–point applications only.

Half–duplex — A high performance protocol that can be used in point–to–point and multi–point applications.

Initiator — A node on the DH–485 network capable of acting as a master. When an initiator has the token it can send messages and request replies from any node on the DH–485 network. A personal computer running the SLC 500 Advanced Programming Software is an initiator on the data link. The SLC 5/02 can also be an initiator.

Input Device — A device, such as a push button or a switch, that supplies signals through input circuits to a programmable controller.

Inrush Current — The temporary surge current produced when a device or circuit is initially energized.

I/O — Inputs and Outputs

Isolated Link Coupler — The link coupler provides an electrically isolated network connection for an SLC 500 controller (processor or programming station). The link couplers connect the daisy–chained DH–485 communication cable.

LED — Light Emitting Diode. Used as status indicator for processor functions and inputs and outputs.

Manual — typically an acoustically coupled type of modem. The connection is established by a person on each end of the phone line. They then insert the handsets into an acoustic coupler to complete the connection.

Maximum Watts — The maximum amount of heat that the module generates with field power present.

Minimum Load Current — The lowest amount of current the output is designed to operate at. Operating at or below this value is not reliable.

Minimum Watts — The amount of heat dissipation that can occur when there is no field power present.

Multi–master network — A network in which more than one node has the ability to initiate communications and initialize the link.

Network — A series of stations (nodes) connected by some type of communication medium. A network may be made up of a single link or multiple links.

Node — Also called a station. An address or software location on the network.

Nominal Input Current — The current at nominal input voltage.

Off–State Current — For input circuits, the maximum amount of leakage current allowed from an input device in its Off–state.

Off–State Leakage — For output circuits, the maximum amount of (leakage) current that may flow when the output circuit is in its Off–state.

Off–State Voltage (max) — The maximum input voltage level detected as an Off condition by the input module.

On–State Voltage Drop — The voltage developed across the output driver circuit during the On state at maximum load current.

Operating Voltage — For inputs, the voltage range needed for the input to be in the On state. For outputs, the allowable range of user–supplied voltage.

Output Device — A device, such as a pilot light or a motor starter coil, that is energized by the programmable controller.

Points per Common — The number of input or output points connected to a single return (common) or supply (vcc).

Protocol — The "language" or packaging of information that is transmitted across a network.

(I/O) Rack — An I/O addressing unit that corresponds to 8 input image–table words and 8 output image–table words. A rack can contain a maximum of 8 I/O groups for up to 128 discrete I/O.

Remote I/O Network — A network where the communication between the processor and the I/O is across a serial link.

Responder —A node on the DH–485 network that acts as a slave device. A responder is not capable of initiating communications. It can only send messages in response to a request from an initiator. The SLC 5/01 and 5/02 can also be responders.

RS–232 — An EIA standard that specifies electrical, mechanical, and functional characteristics for serial binary communication circuits. A single–ended serial communication interface.

RTB —Removable Terminal Block.

Signal Delay — For inputs, the response time required to transmit the circuit status from the field wiring to the digital logic. For outputs, the time required to transmit the circuit status from digital logic to the output wiring.

Sinking — A term used to describe current flow between an I/O device and SLC I/O circuit — typically, a sinking device or circuit provides a path to ground, low, or negative side of power supply.

Sinking/Sourcing — Describes a current signal flow relationship between field input and output devices in a control system and their power supply. Sourcing I/O modules supply (or source) current to sinking field devices. Sinking I/O modules receive (or sink) current from sourcing field devices.

Sourcing — A term used to describe current flow between an I/O device and SLC I/O circuit — typically, a sourcing device or circuit provides a path to the source, high, or positive side of power supply.

Surge Current Per Point — The maximum amplitude and duration (pulse) of current allowed for a given period of time and temperature.

Surge Suppressor — A device used to absorb voltage transients created by energizing an inductive load to reduce electrical noise or to protect the output circuit. For example, an R–C network, MOV (metal oxide varistor) or diode.

Token — The logical right to initiate communications. In a multi–master network a single token is passed between initiators to make sure two nodes do not transmit at the same time.

UVPROM — An Ultra–Violet light erasable Programmable Read Only Memory module used to back up, store, or transfer SLC 500 programs. The SLC 5/01 and 5/02 can only read from a UVPROM. An external PROM programmer is used to program (write to) the device.

Voltage Category — The nominal voltage used to describe the module.

Watts Per Point — The maximum heat dissipation that can occur in each field wiring point when energized.

Numbers

A

U

V

W

Document Update **DU**

SLC 500™
Fixed Hardware Style Installation and Operation Manual

Purpose of this Document

This Document Update revises the Fixed Hardware Style Installation and Operation Manual, Catalog Number 1747–NI001 Series A. Keep this Document Update with your user's manual.

Summary of Update

The following table summarizes the information contained in this Document Update. *Affected page(s)* are the pages being updated. *Action to take* is what you need to do by either updating the page or making a reference to the Document Update. *Addition / correction* summarizes the update. Revision bars appear in the left margin where updated information is located.

Affected Page(s)	Action To Take	Addition/Correction
2–8	Make addition.	Add new subsection entitled *Watch Out for High Voltages!* with new information just before the subsection already entitled *Disconnecting Main Power.*
4–4	Make addition.	Add new information just below the ATTENTION already on the page.
4–5	Make addition.	Add new subsection entitled *Watch Out for High Voltages!* with new information just before the subsection already entitled *High–Speed Counter Operation.*
7–4	Make addition.	Add new information at the beginning of the section entitled *Installing or Replacing Your SLC 500 Battery.*
7–5	Make addition.	Add new information at the beginning of the section entitled *Replacing the Power Supply Fuse.*

Page 2–8

Add a new subsection entitled *Watch Out for High Voltages!*. The text and graphics for this new section is shown on the next page:

Page 4–4

Add the text and graphics shown on the next page.

Page 4–5

Add a new subsection entitled *Watch Out for High Voltages!*. Add the text and graphics shown on the next page.

Page 7–4

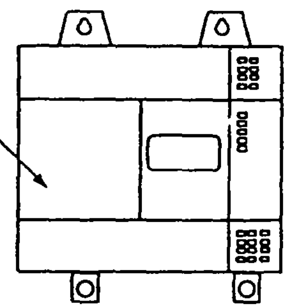
Add the text and graphics shown on the next page.

Page 7–5

Add the text and graphics shown on the next page.

Watch Out for High Voltages!

SLC 500 Fixed Hardware Style Controller (Series C)



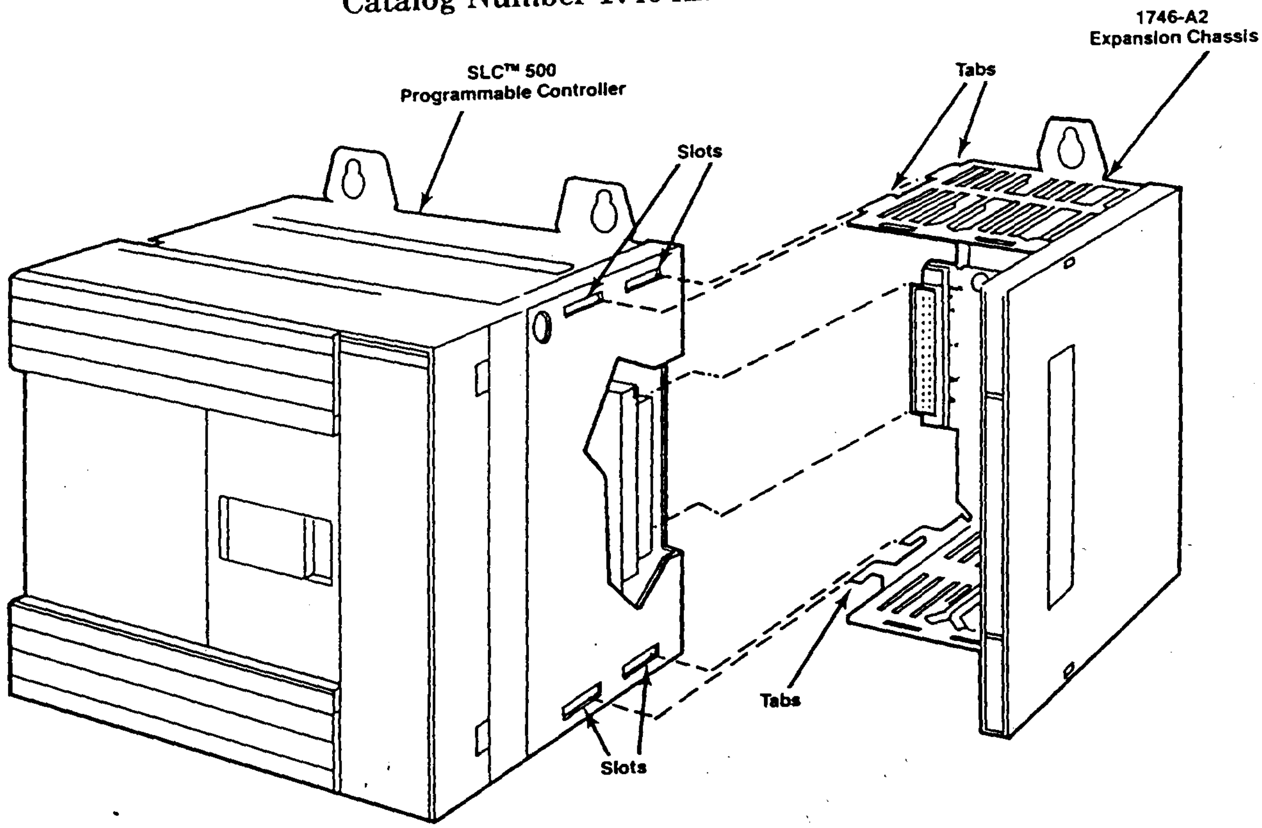
EFFECTS:
All Series C Fixed Hardware Style Controllers with catalog numbers 1747 - L20A, - L30A, -L40A, - L20C,- L30C, and - L40C.

ATTENTION: The printed circuit board, located under the front cover of Series C Fixed Hardware Style Controllers, has high voltages (120 VAC and 240 VAC) available at certain points when the controller is powered up. If the front cover is removed, exercise extreme care and consider all points on the circuit board to be electrically hazardous. Therefore, turn off power to the controller before removing the front cover (see *Important* statement below). The location of the front cover and the list of the effected equipment is shown in the illustration above. *DO NOT* remove the protective insulation covering the circuit board. Cutouts in the insulation are provided to allow access to the high–speed counter jumper, memory module, and battery connector. If the insulation is missing, do not touch any portion of the circuit board. Failure to heed this warning may result in personal injury or death.

Important: There may be situations that warrant keeping processor power on while replacing the battery; for example, certain controlled processes cannot be interrupted. If so, read the warning above *prior to* battery replacement.

Notes

INSTALLATION INSTRUCTIONS
SLC™ 500 PROGRAMMABLE CONTROLLER
2-SLOT EXPANSION CHASSIS
Catalog Number 1746-A2



1. Disconnect power from SLC 500 Controller.

2. Insert upper and lower tabs on Expansion Chassis into slots on SLC 500.

3. Slide Expansion Chassis forward until it is fully seated. The backplane of the Expansion Chassis will be flush with the backplane of the SLC 500 Controller.

40063-061-01(A)

ALLEN-BRADLEY

SLC 500™ Power Supplies

(Catalog Numbers 1746–P1, 1746–P2, 1746–P3, 1746–P4)

Installation Instructions

Overview

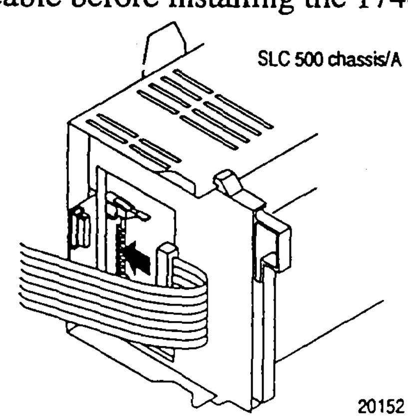
Install your power supply using these installation instructions. The only tools you require are a Flat head (1/8") and a Phillips head (1/4", #2) screwdriver.

ATTENTION: Electrostatic discharge can damage integrated circuits or semiconductors if you touch backplane connector pins. Follow these guidelines when you handle the power supplies.

- Touch a grounded object to discharge static potential.
- Do not touch the backplane connector or connector pins.
- Do not touch circuit components inside the power supply.
- If available, use a static-safe work station.
- When not in use, keep the power supplies in their static-shield packaging.

Install the Chassis Interconnect Cable (Optional)

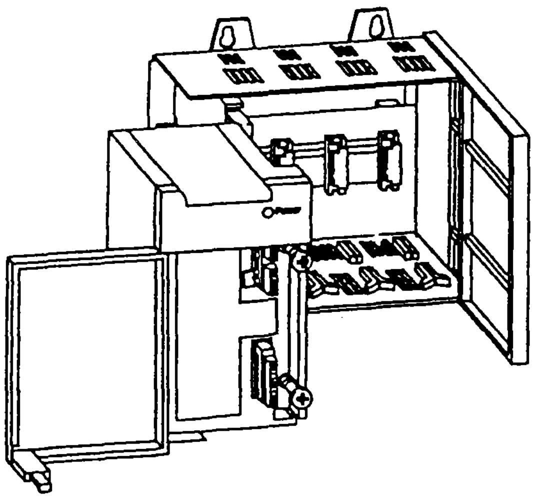
To connect up to three SLC 500™ chassis together, install the chassis interconnect cable before installing the 1746-P1, –P2, –P3, and –P4 power supplies.



For more information, see the *SLC 500 Modular Style Installation and Operation Manual* (publication 1747-6.2).

Power Supply Installation

1. Align the circuit board of the power supply with the card guides on the left side of the chassis.



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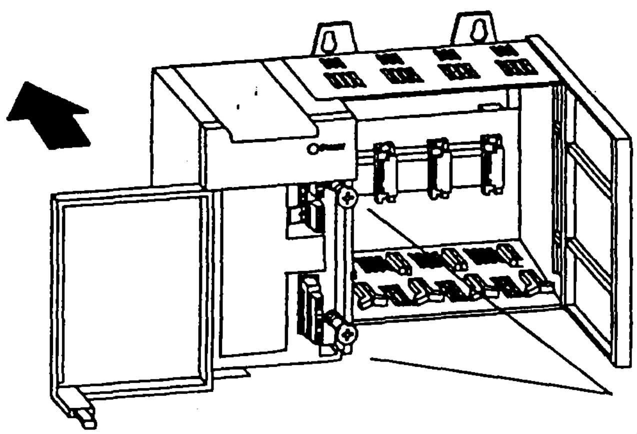
2. Slide the power supply in until it is flush with the chassis. Then fasten the power supply to the chassis.



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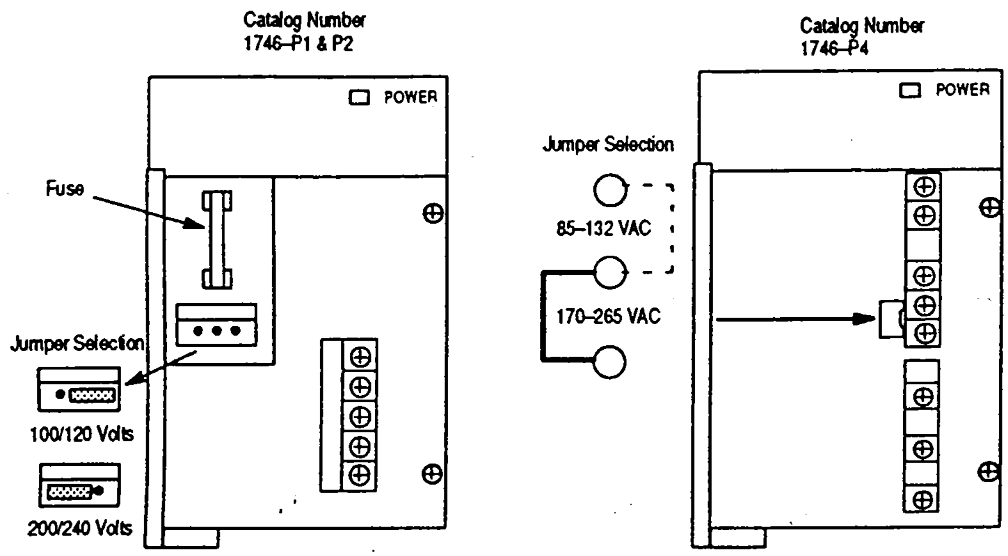
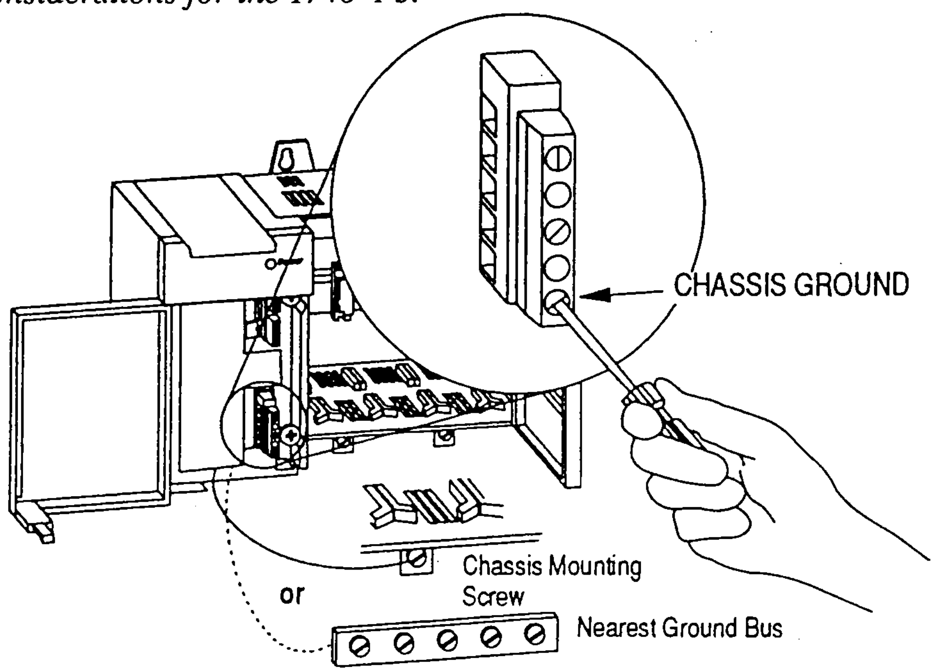
Power Supply Wiring

1. Place the input voltage jumper to match the input voltage. (This does not apply to the 1746–P3, which does not have a jumper.)

ATTENTION: Set the input jumper before applying power. Hazardous voltage is present on exposed pins when power is applied; contact with the pin may cause injury to personnel.

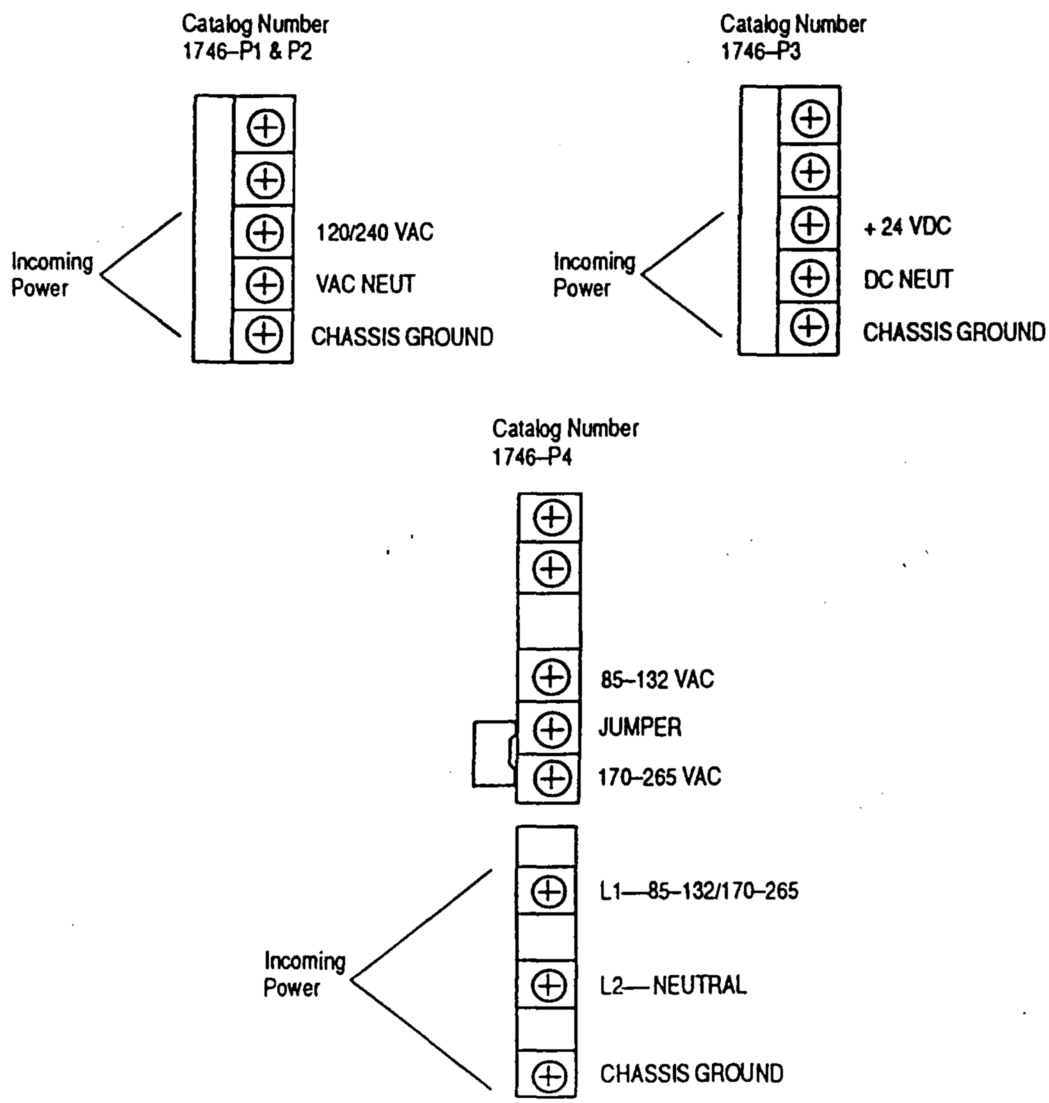


2. Connect the ground screw of the power supply to the nearest ground or ground bus. Use a #14AWG wire and keep the leads as short as possible. The 1746–P4 is shown below. *Refer to page 6 for special wiring considerations for the 1746–P3.*

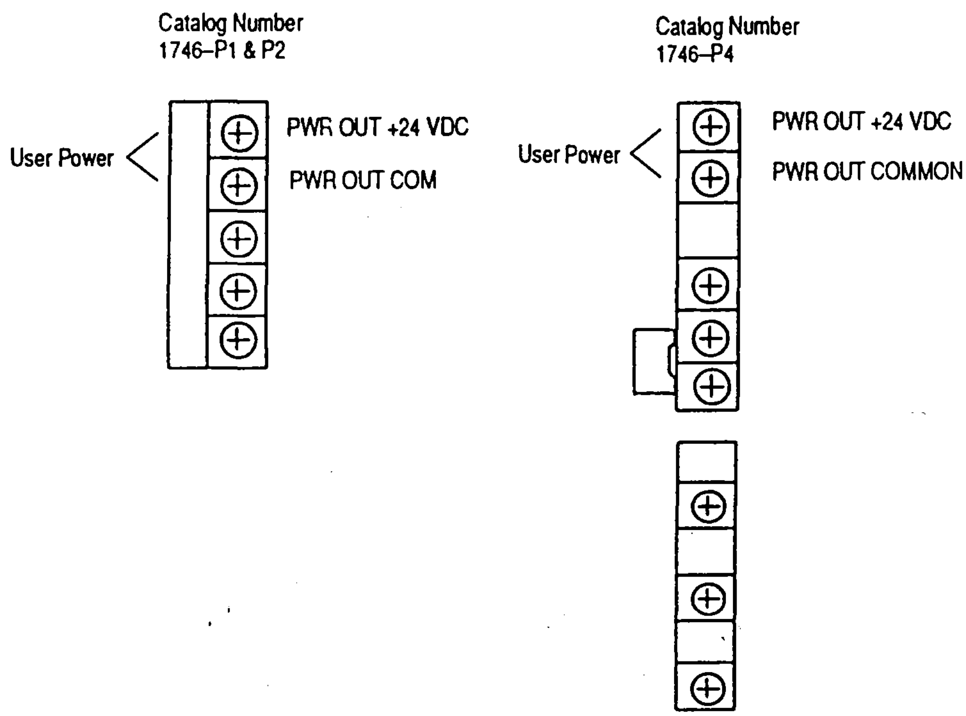


3. Connect incoming power.

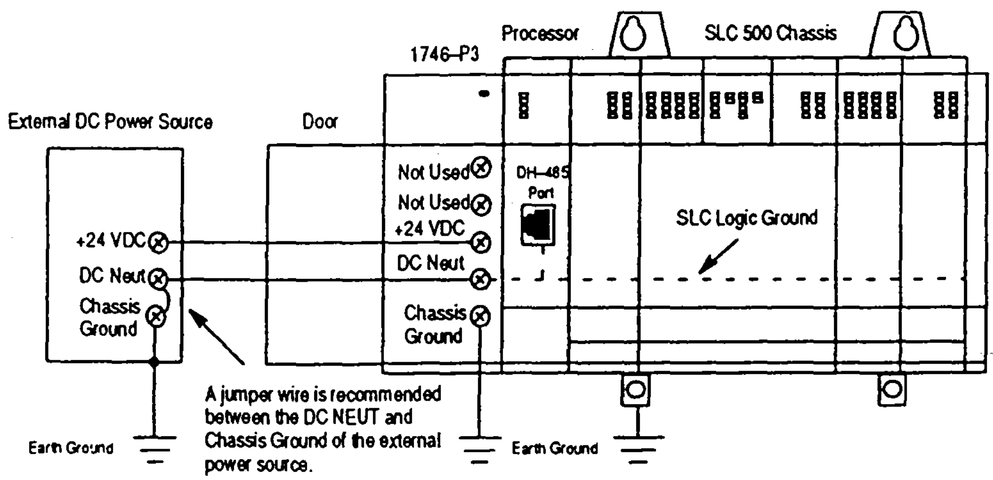
ATTENTION: Turn off incoming power before connecting wires; failure to do so could cause injury to personnel and/or equipment.



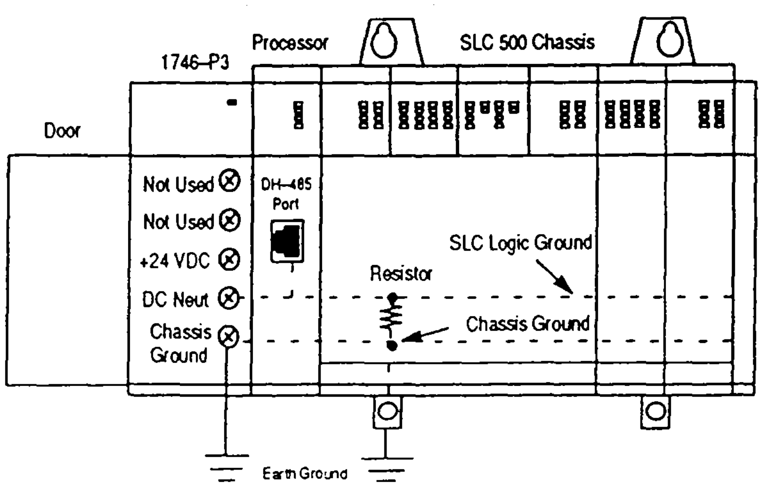
4. **(Optional)** For the 1746–P1, –P2, and –P4 power supplies, use PWR OUT +24 VDC and PWR OUT COM terminals to power 24 VDC sensors and loads. The terminals on the 1746–P1 and 1746–P2 provide an isolated, nonfused 200 mA, 24 VDC power supply. The terminals on the 1746–P4 provide an isolated, nonfused 1A, 24 VDC power supply. (The 1746–P3 power supply does not provide for an external power source.)



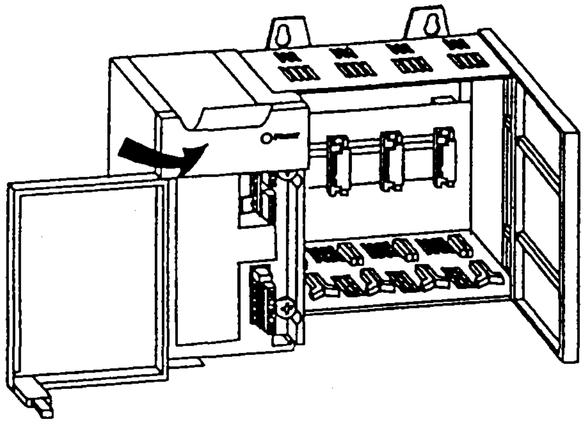
ATTENTION: Any voltage applied to the 1746–P3 DC NEUT terminal will be present at the SLC logic ground and the processor DH–485 port. To prevent unwanted potentials across the logic ground of the controller and/or damage to the SLC chassis, the DC NEUTRAL of the external DC power source must be either isolated from the SLC chassis ground, or connected to earth ground.



Important: SLC 500 Series A chassis (1746–A4, –A7, –A10, and –A13) manufactured *before* November 1992 have a resistor between the logic ground and chassis ground. This resistor could be damaged if the wiring recommendation described within the attention box above is not followed. See the figure below for the location of the resistor. SLC 500 Series A chassis (1746–A4, –A7, –A10, and –A13) with a manufacture date of November 1992 or later do not have this resistor. SLC 500 Series B chassis have a 1MΩ resistor that limits the current between logic ground and chassis ground.



5. Remove the protective label.



Physical Dimensions

Controller: 1746–	Length: mm (in.)	Depth: mm (in.)	Height: mm (in.)
P1	65 (2.56)	140 (5.51)	140 (5.51)
P2	85 (3.35)		
P3	85 (3.35)		
P4	110 (4.33)	145 (5.70)	

General Specifications

Description:	Specification: 1746–			
	P1	P2	P3	P4
Line Voltage	85–132/170–265 VAC 47–63 Hz	85–132/170–265 VAC 47–63 Hz	19.2–28.8 VDC	85–132/170–265 VAC 47–63 Hz
Typical Line Power Requirement	135 VA	180 VA	90 VA	240 VA
Maximum Inrush Current	20A	20A	20A	45A
Internal Current Capacity	2A at 5 VDC 0.46A at 24 VDC	5A at 5 VDC 0.96A at 24 VDC	3.6A at 5 VDC 0.87A at 24 VDC	10.0A at 5 VDC 2.88A at 24 VDC[1]
Fuse Protection[2]	1746–F1 or equivalent: 250V–3A Fuse Nagasawa ULCS–61ML–3 or BUSSMANN AGC 3	1746–F2 or equivalent: 250V–3A Fuse SANO SOC SD4 or BUSSMANN AGC 3	1746–F3 or equivalent: 125V–5A Fuse Nagasawa ULCS–61ML–5 or BUSSMAN AGC 5	Non–replaceable fuse is soldered in place.
24 VDC User Power Current Capacity	200 mA	200 mA	Not Applicable	1A[1]
24 VDC User Power Voltage Range	18–30 VDC	18–30 VDC	Not Applicable	20.4–27.6 VDC
Ambient Operating Temperature	0°C to 60°C (32°F to 140°F) (Current capacity derated 5% above 55°C)			0°C to 60°C (32°F to 140°F) no derating
Certification	UL/CSA			
Hazardous Environment Certification	Class I Division 2			

[1]The combination of all output power (5 volt backplane, 24 volt backplane, and 24 volt user source) cannot exceed 70 Watts.

[2]Power supply fuse is intended to guard against fire hazard due to short circuit conditions and may not protect the supply from damage under overload conditions.

ALLEN-BRADLEY

Discrete I/O Modules
(Cat. No. 1746 Series)

Installation Instructions

Input Module Catalog Numbers:
1746-IA4, -IA8, -IA16, -IM4, -IM8, -IM16, -IN16, -IB8, -IB16 , -ITB16, -IC16, -IV8, -IV16, -ITV16, -IG16,

Output Module Catalog Numbers:
1746-OA8, -OA16, -OAP12, -OB8, -OB16, -OBP8, -OBP16, -OV8, -OV16, -OVP16, -OW4, -OW8, -OW16, -OX8, -OG16

Combination Input/Output Module Catalog Numbers:
1746-IO4, -IO8, -IO12

Table of Contents

Overview

In addition to providing the module's electrical specifications, this document tells you how to:

- install the module into a chassis
- wire the module's terminal block
- install the Octal Filter Label

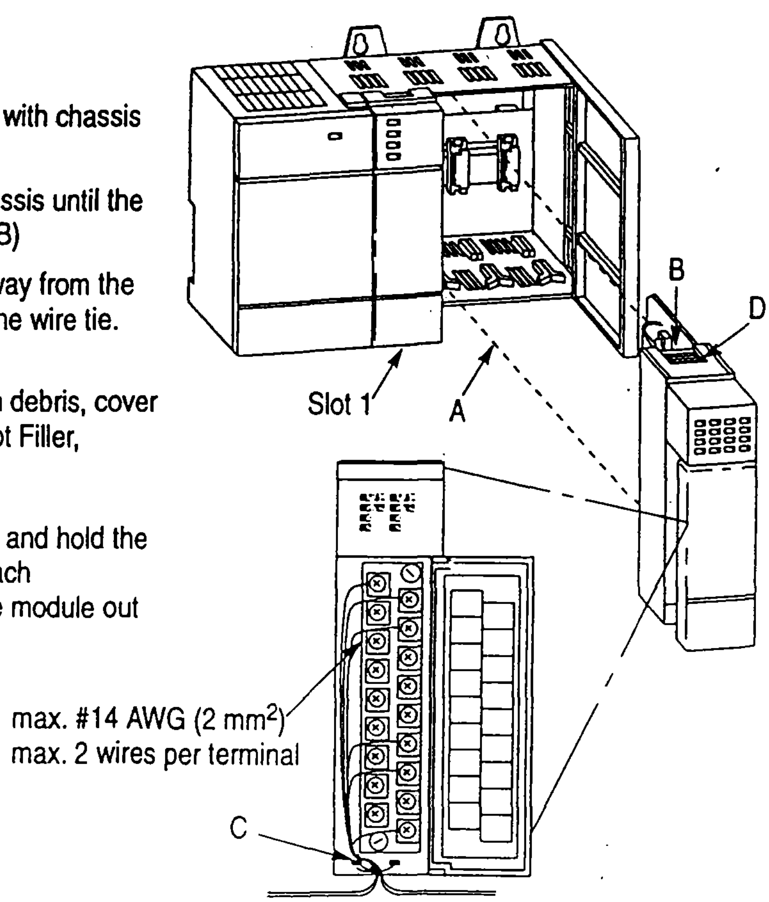
Installation

ATTENTION: Never install, remove, or wire modules with power applied to chassis.

Important: The first slot of the chassis is reserved for the CPU or the 1747-ASB module.

1. Disconnect power.
2. Align circuit board of module with chassis card guide. (A)
3. Slide the module into the chassis until the bottom tabs lock into place. (B)
4. Route the wires down and away from the module, securing them with the wire tie. (C)
5. To keep the chassis free from debris, cover all unused slots with Card Slot Filler, Catalog Number 1746-N2.

To remove the module, press and hold the module release located on each self–locking tab, and slide the module out of the chassis slot. (D)



Specifications

General I/O

Table 1
Specifications for All Discrete Modules

Operating Temperature	0°C to 60°C (32°F to 140°F)①
Storage Temperature	–40°C to 85°C (–40°F to 185°F)
Operating Humidity	5% to 95% (noncondensing)
Noise Immunity	NEMA standard ICS 2–230
Vibration (Operating)	Displacement 0.015 in peak at 5–57 Hz Acceleration 2.5Gs at 57–2000 Hz
Shock (Operating)	30Gs (all modules except relay contact) 10Gs (relay contact modules, -OW, -OX, I/O combo)
Isolation②	1500V
Agency Certification	▪ UL listed ▪ CSA certified ▪ CE compliant for all applicable directives when product or packaging is marked
Hazardous Environment Class③	Class I, Division 2 Hazardous Environment UL-A196, CSA

① Exceptions are indicated with certain modules.

② Electro–optical isolation between I/O terminals and control logic.

③ Some modules are classified Class I, Division 2 by CSA only as shown in the specification table for the respective module.

Specifications

Heat Dissipation

The following tables contain values for the heat dissipated by each I/O module. Use them to calculate the total amount of heat dissipated by your SLC 500 control system. For details on how to calculate total heat dissipation, refer to the *SLC 500 Modular or Fixed Hardware Style Installation and Operation Manual* (Publication Number 1747-6.2 or 1747-NI001). Please note the following definitions:

- *Watts per Point* – the heat dissipation that can occur in each field wiring point when energized at nominal voltage.
- *Minimum Watts* – the amount of heat dissipation that can occur when there is no field power present.
- *Total Watts* – the watts per point plus the minimum watts (with all points energized).

Table 2
Input Module Heat Dissipation

Catalog Numbers	Watts per Point	Minimum Watts	Total Watts
1747-IA4	0.27	0.175	1.30
1746-IA8	0.27	0.250	2.40
1746-IA16	0.27	0.425	4.80
1746-IM4	0.35	0.175	1.60
1746-IM8	0.35	0.250	3.10
1746-IM16	0.35	0.425	6.00
1746-IB8	0.20	0.250	1.90
1746-IB16	0.20	0.425	3.60
1746-ITB16	0.20	0.425	3.60
1746-IV8	0.20	0.250	1.90
1746-IV16	0.20	0.425	3.60
1746-ITV16	0.20	0.425	3.60
1746-IG16	0.020	0.700	1.00
1746-IN16	0.35	0.425	6.00

Specifications

Heat Dissipation (continued)

Table 3
Output Module Heat Dissipation

Catalog Numbers	Watts per Point	Minimum Watts	Total Watts
1746-OA8	1.00	0.925	9.00
1746-OA16	0.462	1.85	9.30
1746-OAP12	1.00	1.85	10.85
1746-OB8	0.775	0.675	6.90
1746-OB16	0.338	1.40	7.60
1746-OBP16	0.31	1.25	6.26
1746-OV8	0.775	.675	6.90
1746-OV16	0.338	1.40	7.60
1746-OVP16	0,31	1.25	6.26
1746-OW4	0.133	1.31	1.90
1746-OW8	0.138	2.59	3.70
1746-OW16	0.033	5.17	5.70
1746-OX8	0.825	2.59	8.60
1746-OG16	0.033	0.900	1.50

Table 4
Combination Input/Output Module Heat Dissipation

Catalog Numbers	Watts per Point	Minimum Watts	Total Watts
1746-IO4	0.27 per input point 0.133 per output point	0.75	1.60
1746-IO8	0.27 per input point 0.133 per output point	1.38	3.00
1746-IO12	0.27 per input point 0.133 per output point	2.13	4.60

Specifications

Input Modules – ac

Table 5
Specifications for Discrete Input Modules 1746-IA4, -IA8, and -IA16

Description:		Specification: 1746-		
		IA4	IA8	IA16 ①
Voltage Category		100/120V ac Signal Input		100/120V ac Signal Input
Number of Inputs		4	8	16
Points per Common		4	8	16
Operating Voltage		85–132V ac at 47–63 Hz		85–132V ac at 47–63 Hz
Backplane Current Consumption	5V	0.035A	0.050A	0.085A
	24V	0.0A	0.0A	0.0A
Signal Delay (max.)		on = 35 ms off = 45 ms	on = 35 ms off = 45 ms	on = 35 ms off = 45 ms
Off State Voltage (max.)		30V ac	30V ac	30V ac
Off State Current (max.)		2 mA	2 mA	2 mA
Nominal Input Current at 120V ac		12 mA	12 mA	12 mA
Inrush Current (max.) ②		0.8A	0.8A	0.8A

① Removable Terminal Block.

② An ac input device must be compatible with SLC 500 input circuit inrush current. A current limiting resistor can be used to limit inrush current; however, the operating characteristics of the ac input circuit will be affected.

Specifications

Input Modules – ac (continued)

Table 6
Specifications for Input Modules 1746-IM4, -IM8, and -IM16

Description:		Specification: 1746-		
		IM4	IM8	IM16①
Voltage Category		200/240V ac Signal Input		
Number of Inputs		4	8	16
Points per Common		4	8	16
Operating Voltage		170–265V ac at 47–63 Hz		
Backplane Current Consumption	5V	0.035A	0.050A	0.085A
	24V	0.0A	0.0A	0.0A
Signal Delay (max.)		on = 35 ms off = 45 ms	on = 35 ms off = 45 ms	on = 35 ms off = 45 ms
Off State Voltage (max.)		50V ac	50V ac	50V ac
Off State Current (max.)		2 mA	2 mA	2 mA
Nominal Input Current at 240V ac		12 mA	12 mA	12 mA
Inrush Current (max.)②		1.6A	1.6A	1.6A

① Removable Terminal Block.

② An ac input device must be compatible with SLC 500 input circuit inrush current. A current limiting resistor can be used to limit inrush current; however, the operating characteristics of the ac input circuit will be affected.

Specifications

Input Modules – dc

Table 7
Specifications for Input Modules 1746-IB8, -IB16, -ITB16, and -IC16

Description:		Specification: 1746-			
		IB8	IB16 ①	ITB16 ①	IC16 ①③
Voltage Category		24V dc Signal Input (sinking)			48V dc Signal Input (sinking)
Number of Inputs		8	16	16	16
Points per Common		8	16	16	16
Operating Voltage		10–30V dc (sinking)			30–60V dc at 55°C 30–55V dc at 60°C (sinking)
Backplane Current Consumption	5V	0.050A	0.085A	0.085A	0.085A
	24V	0.0A	0.0A	0.0A	0.0A
Signal Delay (max.)		on = 8 ms off = 8 ms	on = 8 ms off = 8 ms	on = 0.3 ms off = 0.5 ms ②	on = 4 ms off = 4 ms
Off State Voltage (max.)		5.0V dc	5.0V dc	5.0V dc	10.0V dc
Off State Current (max.)		1 mA	1 mA	1.5 mA	1.5 mA
Nominal Input Current		8 mA @24 V dc			4.1 mA @48 V dc

① Removable Terminal Block.

② Typical signal delay for these modules: ON = 0.1 ms, OFF = 0.25 ms at 24V dc.

③ Use ID Code 0509 when configuring your system with APS or the HHT.

Specifications

Input Modules – dc (continued)

Table 8
Specifications for Input Modules 1746-IV8, -IV16, and -ITV16

Description:		Specification: 1746-		
		IV8	IV16①	ITV16①
Voltage Category		24V dc Signal Input (sourcing)		
Number of Inputs		8	16	16
Points per Common		8	16	16
Operating Voltage		10–30V dc (sourcing)		
Backplane Current Consumption	5V	0.050A	0.085A	0.085A
	24V	0.0A	0.0A	0.0A
Signal Delay (max.)		on = 8 ms off = 8 ms	on = 8 ms off = 8 ms	on = 0.3 ms off = 0.5 ms②
Off State Voltage (max.)		5.0V dc	5.0V dc	5.0V dc
Off State Current (max.)		1 mA	1 mA	1.5 mA
Nominal Input Current at 24V dc		8 mA	8 mA	8 mA

① Removable Terminal Block.

② Typical signal delay for these modules: ON = 0.1 ms, OFF = 0.25 ms at 24V dc.

Specifications

Input Modules – dc (continued)

Table 9
Specifications for Input Modules 1746-IG16

Description:		1746-IG16 ①
Voltage Category		5V dc TTL Signal Input (sourcing) ②
Number of Inputs		16
Points per Common		16
Operating Voltage		4.5–5.5V dc (sourcing)
Backplane Current Consumption	5V	0.140A
	24V	0.0A
Signal Delay (max.)		on = 0.25 ms off = 0.50 ms
Off State Voltage (max.)		2.0V dc ③
Off State Current (max.)		4.1 mA
Nominal Input Current at 5V dc		3.7 mA

① Removable Terminal Block.

② User supplied voltage: 4.5 – 5.5V dc, 50mV peak to peak ripple (max.).

③ TTL inputs are inverted (–0.2 to +0.8V dc = low voltage = True = ON). Use a NOT instruction in your ladder program to convert to traditional True = High logic.

Specifications

Input Modules – dc (continued)

Table 10
Specifications for Input Modules 1746-IN16

Description:		1746-'N16①
Voltage Category		24V ac/dc Signal Input
Number of Inputs		16
Points per Common		16
Operating Voltage	dc	10–30V dc (sinking)
	ac	10–30V ac
Backplane Current Consumption	5V	0.085A
	24V	0.0A
Signal Delay (max.)	dc	on = 15 ms off = 15 ms
	ac	on = 25 ms off = 25 ms
Off State Voltage (max.)	dc	3.0V dc
	ac	3.0V ac
Off State Current (max.)	dc	1mA
	ac	1 mA
Nominal Input Current at 24V dc and 24V ac	dc	8 mA
	ac	8 mA
Inrush Current (max.)		0.02A (ac only)

① Removable Terminal Block.

Specifications

Output Modules – ac

Table 11
Specifications for Output Modules 1746-OA8, -OA16, -OAP12

Description:		Specification: 1746-		
		OA8	OA16[1]	OAP12[1][2][3][4]
Voltage Category		120/240V ac Signal Input		
Number of Outputs		8	16	12
Points per Common		4	8	6
Operating Voltage		85–265V ac at 47–63 Hz		
Backplane Current Consumption	5V	0.185A	0.370A	0.370A
	24V	0.0A	0.0A	0.0A
Signal Delay (max.). Resistive Load.[5]		on = 1 ms off = 11.0 ms	on = 1 ms off = 11.0 ms	on = 1 ms off = 11.0 ms
Off State Leakage (max.)[6]		2 mA	2 mA	2 mA
Load Current (min.)		10 mA	10 mA	10 mA
Continuous Current per Point[7]		1.0A at 30°C 0.50A at 60°C	0.50A at 30°C 0.25A at 60°C	2.0A at 30°C 1.25A at 55°C 1.0A at 60°C
Continuous Current per Module		8.0A at 30°C 4.0A at 60°C	8.0A at 30°C 4.0A at 60°C	9.0A at 30°C 6.0A at 60°C
On–State Voltage Drop (max.)		1.50V at 1.0A	1.50V at 0.50A	1.2V at 2.0A
Surge Current per Point[8]		10.0A for 25 ms	10.0A for 25 ms	17.0A for 25 ms[9]

[1] Removable Terminal Block.

[2] A fused common and blown fuse LED are provided on this module. See pages 24 through 31 for blown fuse diagnostics and replacement.

[3] Use I.D. code 2803 when configuring your system with APS or the HHT.

[4] Certified for Class I, Division 2 hazardous location by CSA.

[5] Triac outputs turn on at any point in the ac line cycle and turn off at ac line zero cross.

[6] To limit the effects of leakage current thru solid state outputs, a loading resistor can be connected in parallel with your load. For 120V ac operation use a 15K Ω, 2W resistor. For 240V ac operation use a 15K Ω, 5W resistor.

[7] *Recommended surge suppression:* For triac outputs when switching 120V ac inductive loads use Harris MOV part number V220MA2A.

[8] Repeatability is once every 1s at 30°C. Repeatability is once every 2s at 60°C.

[9] Surge current = 35A per common for 10 ms.

Specifications

Output Modules – dc

Table 12
Specifications for Output Modules 1746-OB8, -OB16, -OBP8, and -OBP16

Description:		Specification: 1746-			
		OB8	OB16[1]	OBP8[1][4]	OBP16[1][3][4][5]
Number of Outputs		8	16	8	16
Points per Common		8	16	4	16
Voltage Category		24V dc Signal Output			
Operating Voltage (V dc)		10–50 (source)	10–50 (source)	20.4–26.4 (source)	20.4–26.4 (source)
Backplane Current Consumption	5V	0.135A	0.280A	0.135A	0.250A
	24V	0.0A	0.0A	0.0A	0.0A
Signal Delay (max.). Resistive Load.		on = 0.1 ms off = 1.0 ms	on = 0.1 ms off = 1.0 ms	on = 1.0 ms off = 2.0 ms	on = 0.1 ms[2] off = 1.0 ms
Off State Leakage (max.)[6]		1 mA	1 mA	1 mA	1 mA
Load Current (min.)		1 mA	1 mA	1 mA	1 mA
Continuous Current per Point[7]		1.0A at 30°C 0.50A at 60°C	0.50A at 30°C 0.25A at 60°C	2.0A at 60°C	1.5A at 30°C[8] 1.0A at 60°C
Continuous Current per Module		8.0A at 30°C 4.0A at 60°C	8.0A at 30°C 4.0A at 60°C	8.0A at 60°C	6.4A at 0° to 60°C
On–State Voltage Drop (max.)		1.20V at 1.0A	1.20V at 0.50A	1.0V at 2.0A	1.0V at 1.0A
Surge Current per Point[9]		3.0A for 10 ms	3.0A for 10 ms	4.0A for 10 ms	4.0A for 10 ms[10]

[1] Removable Terminal Block.

[2] This module provides fast OFF delay for inductive loads. Comparative OFF delay times for 1746-OB8/-OV8 and 1746-OBP16/-OVP16, when switching Bulletin 100-B110 (24 watts sealed) contactor, are:
1746-OB8/-OV8 OFF delay = 152 ms; 1746-OBP16/-OVP16 OFF delay = 47 ms

[3] A fused common and blown fuse LED are provided on this module. See pages 24 through 31 for fuse blown diagnostics and replacement.

Continued on following page.

④ Use the following I.D. code when configuring your system with APS or the HHT: 1746-OBP8 = 2721 and 1746-OBP16 = 2921.

⑤ Certified for Class I, Division 2 hazardous location by CSA.

⑥ To limit the effects of leakage current thru solid state outputs, a loading resistor can be connected in parallel with your load. For transistor outputs, 24V dc operation, use a 5.6K ohm, 1/2 watt resistor.

⑦ *Recommended surge suppression:* For transistor outputs when switching 24V dc inductive loads use a IN4004 diode reverse–wired across the load (also see footnote 8).

⑧ Fast off delay for inductive loads is accomplished with surge suppressors on the 1746-OBP16 and -OVP16 modules. A suppressor at the load is not needed unless another contact is connected in series. If this is the case, a 1N4004 diode should be reverse wired across the load. This defeats the fast turn off feature.

⑨ Repeatability is once every 1s at 30°C. Repeatability is once every 2s at 60°C.

⑩ Surge current = 32A per module for 10 ms.

ATTENTION: A transient pulse occurs in transistor outputs when the external dc supply voltage is applied to the output common terminals (e.g., via the master control relay). This can occur regardless of the processor having power or not. For most applications, the energy of this pulse is not sufficient to energize the load. Refer to the *SLC 500 Modular or Fixed Hardware Style Installation and Operation Manual* (Publication Number 1747-6.2 or 1747-NI001) for more information on transient pulses and guidelines to reduce inadvertant processor operation.

Specifications

Output Modules – dc (continued)

Table 13
Specifications for Output Modules 1746-OV8, -OV16, -OVP16

Description:		Specification: 1746-		
		OV8	OV16①	OVP16①③④⑤
Number of Outputs		8	16	16
Points per Common		8	16	16
Voltage Category		24V dc Signal Output		
Operating Voltage (V dc)		10–50 (sink)	10–50 (sink)	20.4–26.4 (sink)
Backplane Current Consumption	5V	0.135A	0.270A	0.250A
	24V	0.0A	0.0A	0.0A
Signal Delay (max.). Resistive Load.		on = 0.1 ms off = 1.0 ms	on = 0.1 ms off = 1.0 ms	on = 0.1 ms② off = 1.0 ms
Off State Leakage (max.)⑥		1 mA	1 mA	1 mA
Load Current (min.)		1 mA	1 mA	1 mA
Continuous Current per Point⑦		1.0A at 30°C 0.50A at 60°C	0.50A at 30°C 0.25A at 60°C	1.5A at 30°C⑧ 1.0A at 60°C
Continuous Current per Module		8.0A at 30°C 4.0A at 60°C	8.0A at 30°C 4.0A at 60°C	6.4A at 0° to 60°C
On–State Voltage Drop (max.)		1.20V at 1.0A	1.20V at 0.50A	1.0V at 1.0A
Surge Current per Point⑨		3.0A for 10 ms	3.0A for 10 ms	4.0A for 10 ms⑩

① Removable Terminal Block.

② This module provides fast OFF delay for inductive loads. Comparative OFF delay times for 1746-OB8/-OV8 and 1746-OBP16/-OVP16 when switching Bulletin 100-B110 (24W) contactor are: 1746-OB8/-OV8 OFF delay = 152 ms. 1746-OBP16/-OVP16 OFF delay = 47 ms.

③ A fused common and blown fuse LED are provided on this module. See pages 24 through 31 for blown fuse diagnostics and replacement.

④ Use the following I.D. code when configuring your system with APS or the HHT: 1746-OVP16 = 2922.

Continued on following page.

⑤ Certified for Class I, Division 2 hazardous location by CSA.

⑥ To limit the effects of leakage current thru solid state outputs, a loading resistor can be connected in parallel with your load. For transistor outputs, 24V dc operation, use a 5.6K Ω, 1/2W resistor.

⑦ *Recommended surge suppression:* For transistor outputs when switching 24V dc inductive loads use a IN4004 diode reverse–wired across the load. (also see footnote 8.)

⑧ Fast off delay for inductive loads is accomplished with surge suppressors on the 1746-OBP16 and -OVP16 modules. A suppressor at the load is not needed unless another contact is connected in series. If this is the case, a 1N4004 diode should be reverse wired across the load. This defeats the fast turn off feature.

⑨ Repeatability is once every 1s at 30°C. Repeatability is once every 2s at 60°C.

⑩ Surge current = 32A per module for 10 ms.

ATTENTION: A transient pulse occurs in transistor outputs when the external dc supply voltage is applied to the output common terminals (e.g., via the master control relay). This can occur regardless of the processor having power or not. For most applications, the energy of this pulse is not sufficient to energize the load. Refer to the *SLC 500 Modular or Fixed Hardware Style Installation and Operation Manual* (Publication Number 1747-6.2 or 1747-NI001) for more information on transient pulses and guidelines to reduce inadvertant processor operation.

Specifications

Output Modules – dc (continued)

Table 14
Specifications for Output Modules 1746-OG16

Description:		Specification: 1746-OG16①
Number of Outputs		16
Points per Common		16
Voltage Category		5V dc TTL Signal Input (sinking)
Operating Voltage		4.5–5.5 V dc②③
Backplane Current Consumption	5V	0.180A
	24V	0.0A
Signal Delay (max.). Resistive Load.		on=0.25 ms off=0.50 ms
Off State Leakage (max.)		0.1 mA
Load Current (min.)		0.15 mA
Continuous Current per Point		24 mA

① Removable Terminal Block.

② User supplied voltage: 4.5 – 5.5V dc, 50mV peak to peak ripple (max.).

③ TTL outputs are inverted (0 to 0.4V dc = low voltage = True = ON). Use a NOT instruction in your ladder program to convert to traditional True = High logic.

Specifications

Relay Contact Output Modules

Table 15
Specifications for Output Modules 1746-OW4, -OW8, -OW16, -OX8

Description:		Specification: 1746-			
		OW4 ①	OW8 ①	OW16 ①②	OX8 ①②
Number of Outputs		4	8	16	8
Points per Common		4	4	8	Individually Isolated
Voltage Category		ac/dc Relay			
Operating Voltage	V dc	5–125	5–125	5–125	5–125
	V ac	5–265	5–265	5–265	5–265
Backplane Current Consumption	5V	0.045A	0.085A	0.170A	0.085A
	24V	0.045A	0.090A	0.180A	0.090A
Signal Delay (max.). Resistive Load.		on = 10.0 ms off = 10.0 ms	on =10.0 ms off = 10.0 ms	on = 10.0 ms off = 10.0 ms	on = 10.0 ms off = 10.0 ms
Off State Leakage (max.)		0 mA	0 mA	0 mA	0 mA
Load Current (min.)		10mA at 5V dc	10mA at 5V dc	10mA at 5V dc	10mA at 5V dc
Continuous Current per Point ③		See relay contact rating tables (Table 17 and Table 18).			
Continuous Current per Module		8.0A ac 8.0A /Common	16.0A ac 8.0A /Common	16.0A ac 8.0A /Common	④

① Certified for Class I, Division 2 hazardous location by CSA.

② Removable Terminal Block.

③ *Recommended surge suppression:* For relay contact outputs consult the SLC 500 Installation and Operation Manual (Cat. No. 1747-6.2). Connecting surge suppressors across your external inductive load will extend the life of SLC 500 relay contacts.

④ The continuous current per module must be limited so the module power does not exceed 1440 VA.

Specifications

Relay Contact Ratings

Table 16
Relay Contact Rating Table for Output Modules 1746-OW4, -OW8, -OW16

Voltages:		Amperes ①		Amperes Continuous ②	Volt-Amperes	
		Make	Break		Make	Break
Maximum Volts (ac)	120	15	1.5	2.5	1800	180
	240	7.5	0.75			
Maximum Volts (dc)	125	0.22③		1.0	28	
	24	1.2③		2.0	28	

Table 17
Relay Contact Rating Table for Output Module 1746-OX8

Voltages:		Amperes ①		Amperes Continuous ②	Volt-Amperes	
		Make	Break		Make	Break
Maximum Volts (ac)	120	30	3.0	5.0	3600	360
	240	15	1.5			
Maximum Volts (dc)	125	0.22③		1.0	28	
	24	1.2③		2.0	28	

① *Recommended surge suppression:* For relay contact outputs consult the SLC 500 Installation and Operation Manual (Cat. No. 1747-6.2). Connecting surge suppressors across your external inductive load will extend the life of SLC 500 relay contacts.

② The continuous current per module must be limited so the module power does not exceed 1440 VA.

③ For dc voltage applications, the make/break ampere rating for relay contacts can be determined by dividing 28 VA by the applied dc voltage. For example, 28 VA ÷ 48V dc = 0.58A. For dc voltage applications less than 14V, the make/break ratings for relay contacts cannot exceed 2A.

Specifications

Input/Output Combination Modules

Table 18
Specifications for Combination Module 1746-IO4, -IO8, -IO12

Description:		Specifications: 1746-		
		IO4①②	IO8①②	IO12①③④
Points per Module		2 inputs 2 outputs	4 inputs 4 outputs	6 inputs 6 outputs
Points per Common		2	4	6
Voltage Category (Inputs)		Inputs–120V ac		
Operating Voltage (Inputs)		85–132V ac		
Voltage Category (Outputs)		Relay contact output		
Operating Voltage (Outputs)		5–265V ac 5–125V dc		
Backplane Current Consumption	5V	0.030A	0.060A	0.090A
	24V	0.025A	0.045A	0.070A

① Certified for Class I, Division 2 hazardous location by CSA.

② See specifications for Catalog Numbers 1746-IA4 and 1746-OW4. Continuous Current per 1746-IO4 Module is 4.0A. Continuous Current per 1746-IO8 Module is 8.0A.

③ Removable Terminal Block.

④ See specifications for Catalog Numbers 1746-IA16 and 1746-OW16. Continuous Current per 1746-IO12 Module is 8.0A.

Octal Label Kit Installation (for PLC Processors Only)

The octal label kit consists of an octal filter label and a door label. Use these octal labels to replace the decimal labels that are attached to the I/O modules. Octal label kit is included with the I/O modules and can also be obtained through your Allen-Bradley distributor.

ATTENTION: Do not touch or remove the terminal block when the SLC 500 system is powered. Contact with ac line potential may cause injury to personnel.

Applying the Octal Filter Label

1. Remove the octal filter label from its paper carrier.
2. Align the octal filter label numbers horizontally to the module color bar and over the decimal filter numbers.
3. Apply the octal label to the filter.
4. Press firmly to ensure proper adhesion of the label.

Applying the Octal Door Label

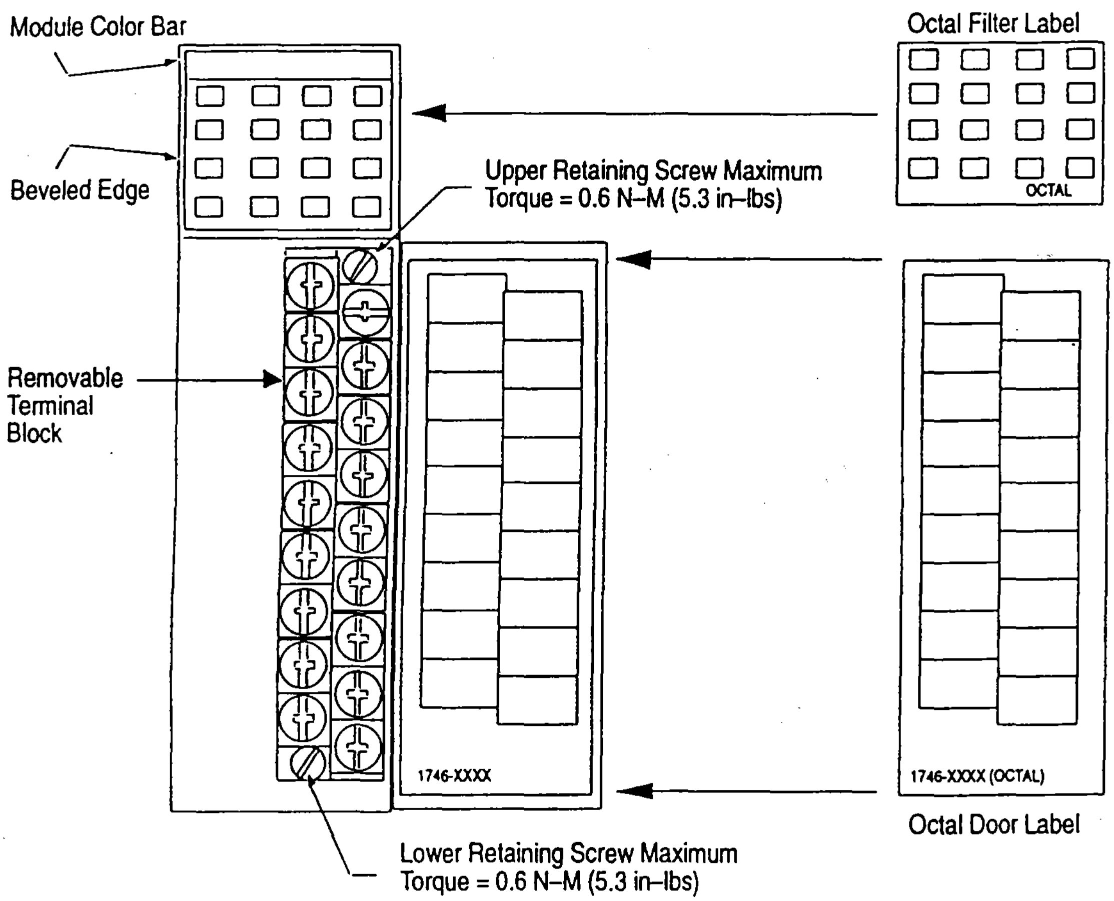
1. Remove the octal door label from its paper carrier.
2. Align the octal label directly over the decimal door label on the inside of the door.
3. Press firmly to ensure proper adhesion of the label.

Octal Label Kit Installation (for PLC Processors Only)

Removable Terminal Blocks

Colored terminal blocks are removable by loosening the upper and lower retaining screws. Black terminal blocks are not removable.

Figure 1
Installing Octal Labels



Fuse Protection and Blown Fuse Diagnostics

This section describes fusing characteristics for the following modules:

- Catalog 1746-OBP16
- Catalog 1746-OVP16
- Catalog 1746-OAP12

Fuse Protection (1746-OBP16 and 1746-OVP16)

The fuse on the 1746-OBP16 and 1746-OVP16 modules (Figure 2) has been designed to provide short circuit protection for wiring only (16 AWG or larger) to external loads. In the event of a short circuit on an output channel, it is likely that the transistor associated with that channel will be damaged and the module should be replaced or a spare output channel used for the load. The fuse does not provide overload protection. In the event of an overload on an output channel, it is likely that the fuse will not blow and the transistor associated with that channel will be damaged. To provide overload protection for your application, user supplied fuses should be installed externally and properly sized to match your individual load characteristics.

Fuse Protection (1746-OAP12)

A fuse is provided on each common of the 1746-OAP12 module (Figure 3) for a total of 2 fuses. The fuses are designed to protect the module from short circuit conditions. The fuse does not provide overload protection. In the event of an overload on an output channel, it is likely that the fuse will not blow and the output device associated with that channel will be damaged. To provide overload protection for your application, user supplied fuses should be installed externally. Recommended fuse for overload protection is SAN–O HT. Select the fuse rating according to your load. Do not use HT fuses rated higher than 2.0 amps.

Blown Fuse Diagnostics

If the fuse blows on the 1746-OBP16, -OVP16 or -OAP12, the following occurs:

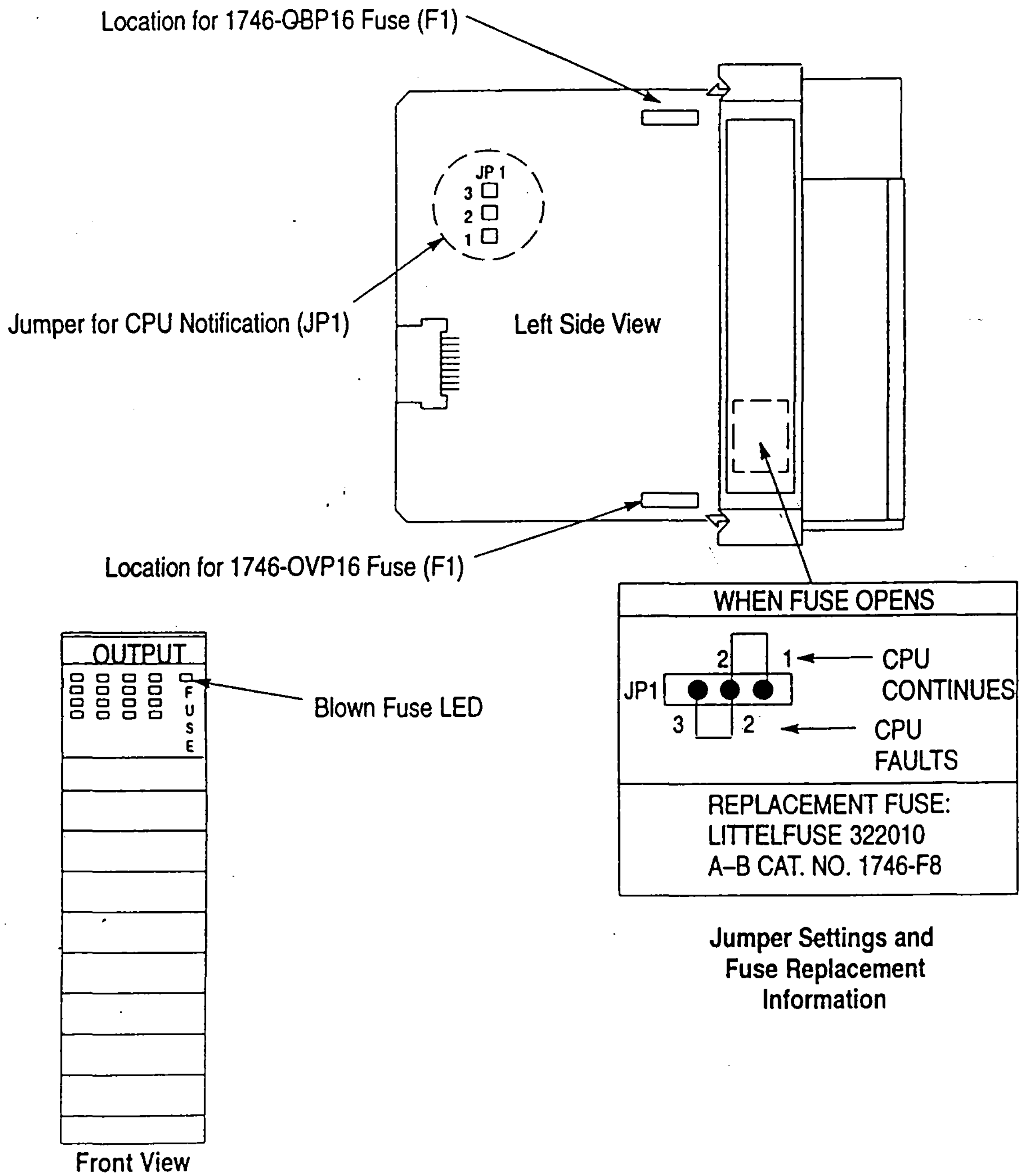
1. The blown fuse LED will illuminate provided power (5V dc via backplane and load power via external supply) is applied to the module.

2. A CPU error will occur if JP1 connects pins 2 and 3. (See Figure 2 and Figure 3.)

Fuse Protection and Blown Fuse Diagnostics

Blown Fuse Diagnostics (continued)

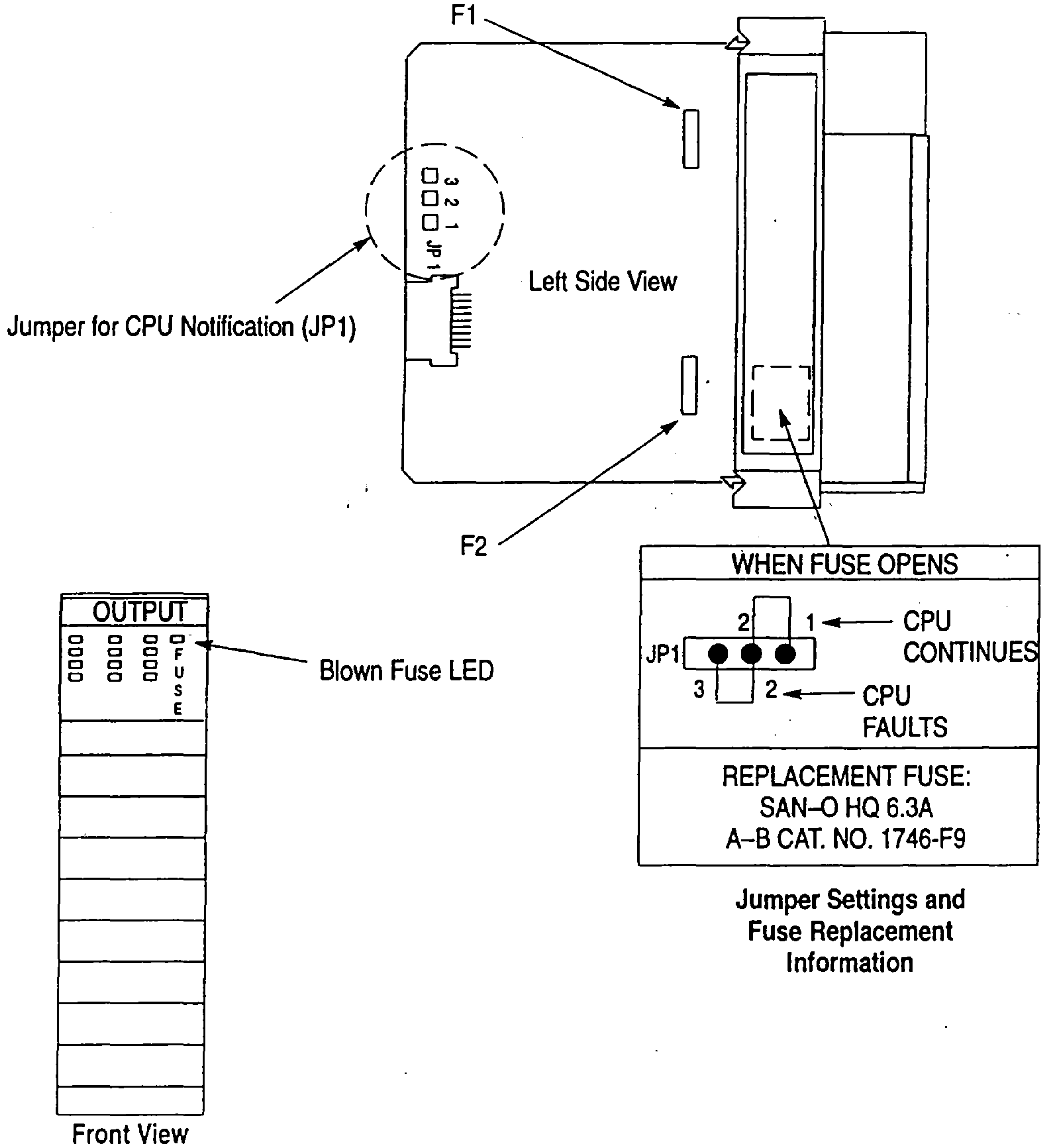
Figure 2
Location of Jumpers and Fuses for 1746-OBP16 and -OVP16



Fuse Protection and Blown Fuse Diagnostics

Blown Fuse Diagnostics (continued)

Figure 3
Location of Jumpers and Fuses for 1746-OAP12

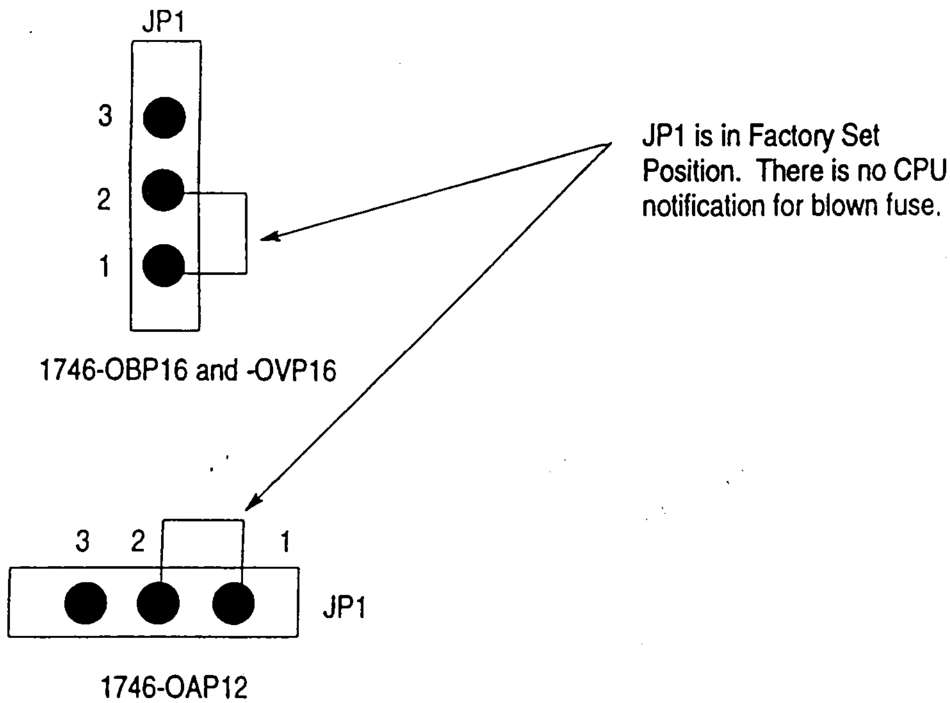


Fuse Protection and Blown Fuse Diagnostics

CPU Operation in case of blown fuse (CPU Continues)

The factory set position for JP1 is shown in Figure 4. For this JP1 configuration, the CPU operation will continue if the module fuse blows.

Figure 4
JP1 Factory Set Position (No CPU Notification)



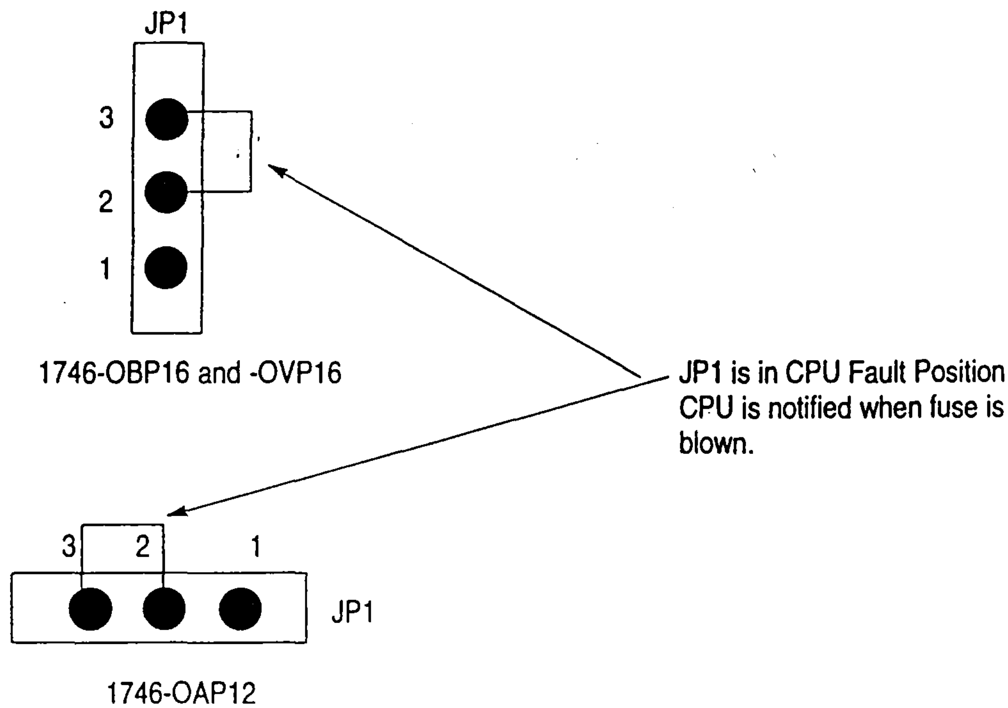
Fuse Protection and Blown Fuse Diagnostics

CPU Operation in case of blown fuse (CPU Faults)

The CPU Fault position for JP1 is shown in Figure 5. For this JP1 configuration, the CPU generates a Non–Recoverable Error for all SLC 500 CPUs (Fixed and Modular). For a non–recoverable error, note the following:

- CPU operation halts and the CPU fault light flashes.
- All outputs are reset to OFF.
- The CPU major fault bit S:1/13 is set.
- Monitor CPU status file word S:6 for error code xx58 for SLC 500 and 5/01 CPUs, error code xx60 for SLC 5/02, SLC 5/03 and SLC 5/04 CPUs.

Figure 5
JP1 in CPU Fault Notification Position



Important: When using SLC 5/02, SLC 5/03, and SLC 5/04 CPUs, a user fault routine cannot be used to clear the major fault bit.

Fuse Protection and Blown Fuse Diagnostics

CPU Operation in case of blown fuse (CPU Faults) (continued)

ATTENTION: For 1746-OBP16/-OVP16, all outputs on the module are OFF if the fuse blows. For 1746-OAP12, all outputs on the same common as the blown fuse are OFF if the fuse blows. If CPU operation is allowed to continue after a blown fuse, extreme care should be taken to ensure the safety of personnel and guard against equipment damage.

For additional information on CPU fault codes and user fault routines refer to the following user manuals:

- APS Instruction Set Reference Manual
- HHT User Manual (Publication 1747-NP002) –
  (a) Chapter 28, Troubleshooting Faults
  (b) Chapter 29, Understanding the Fault Routine

Table 19 defines operation of SLC 500 CPUs in the case of a blown fuse in a 1746-OBP16, -OVP16 and -OAP12:

Table 19
CPU Operation After A Blown Fuse (1746-OBP16, -OVP16 and -OAP12)

Processor	JP1 Set to CPU Continues	JP1 Set to CPU Faults
SLC 500 Fixed, SLC 5/01, SLC 5/02, SLC 5/03, and SLC 5/04	No error. CPU continues with 1746-OBP16/-OVP16 outputs de–energized. 1746-OAP12 outputs, on the same common as the blown fuse, are de–energized.	Non–recoverable error. CPU operations stops and all outputs reset to OFF.

Fuse Protection and Blown Fuse Diagnostics

Recovery From Blown Fuse/CPU fault/CPU Shutdown

CPU operation will stop under the following conditions:

- The output module fuse blows due to a short circuit.
- JP1 is set to the *CPU Faults* position (pins 2 and 3 connected).

If the above conditions occur, the following procedures should be used for recovery:

1. Follow fuse replacement procedures shown below.
2. Clear the CPU major fault bit S:1/13.
3. Clear CPU status file S:6 major error code (optional).
4. Return CPU to Run Mode.

For additional information on CPU fault codes and clearing CPU fault bits, refer to the following user manuals:

- APS Instruction Set Reference Manual
- HHT User Manual (Publication 1747-NP002) –
  (a) Chapter 28, Troubleshooting Faults
  (b) Chapter 29, Understanding the Fault Routine

Replacement Fuse Recommendations

Use the following replacement fuses –

- 1746-OBP16/-OVP16 –Littelfuse #322010 ,10A. This fuse is required to maintain UL/CSA rating. Replacement Fuse Kit catalog number is 1746-F8. (5 fuses per kit).
- 1746-OAP12 –Use SAN–O HQ 6.3A for replacement. This fuse is required to maintain UL/CSA rating. Replacement Fuse Kit is catalog number is 1746-F9 (5 fuses per kit).

Fuse Protection and Blown Fuse Diagnostics

Fuse Replacement Procedure

To replace a blown fuse:

ATTENTION: Never install, remove, or wire modules with power applied to chassis.

---

1. Remove SLC 500 system power and correct the conditions causing the short circuit.
2. Remove the output module from the chassis.
3. Remove the fuse.
   - 1746-OBP16/-OVP16: Use a wide tipped, slotted head screw driver to remove the blown fuse. Slide the screw driver tip under the fuse and use a twisting motion to pry the fuse from the fuse clip. Use care so that the printed circuit board and surrounding electronics are not damaged.
   - 1746-OAP12: A fuse holder is provided with each fuse. Simply grasp the fuse holder with needle–nose pliers, or your fingers, and pull it out.
4. Replace the fuse.
   - 1746-OBP16/OVP16: Center the replacement fuse over the fuse clip and press down. If a tool is used to press the fuse in place, apply pressure to the metal end caps only, not the center of the fuse.
   - 1746-OAP12: Insert a new fuse into the fuse holder, align fuse holder on fuse clips and press down.
5. Replace the output module in the chassis.
6. Restore SLC 500 system power. Clear CPU fault bits as indicated in the steps provided on page 29.

Wiring Diagrams

The wiring diagrams in these installation instructions are examples only. It is not necessary to connect an I/O device to each and every I/O module terminal.

Labeling for SLC/PLC Systems

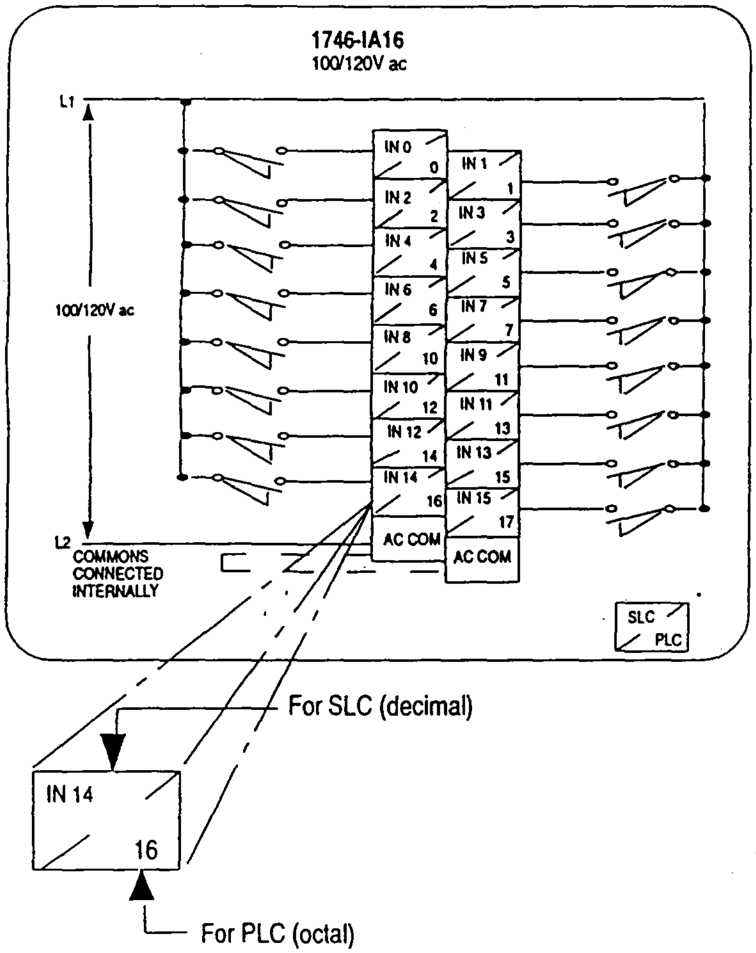
In this document, 16 point I/O module wiring diagrams include both decimal and octal numbers for I/O addressing and wire identification (Figure 6). To wire your 16 point I/O module when used in a SLC system, use the decimal numbers in the upper left portion of each box. When used in a PLC system, use the octal numbers in the lower right portion of the box. *As shipped from the factory, the I/O module has a decimal address label on the inside of its door.* An octal label kit should be included with your 16 point I/O modules, or a separate octal conversion kit can be ordered, to allow you to convert your module to the octal system.

Important: Ensure the octal labels are used with your PLC system. Directions on how to install the labels are included with the kit and on page 22 of this document.

Wiring Diagrams

Labeling for SLC/PLC Systems (continued)

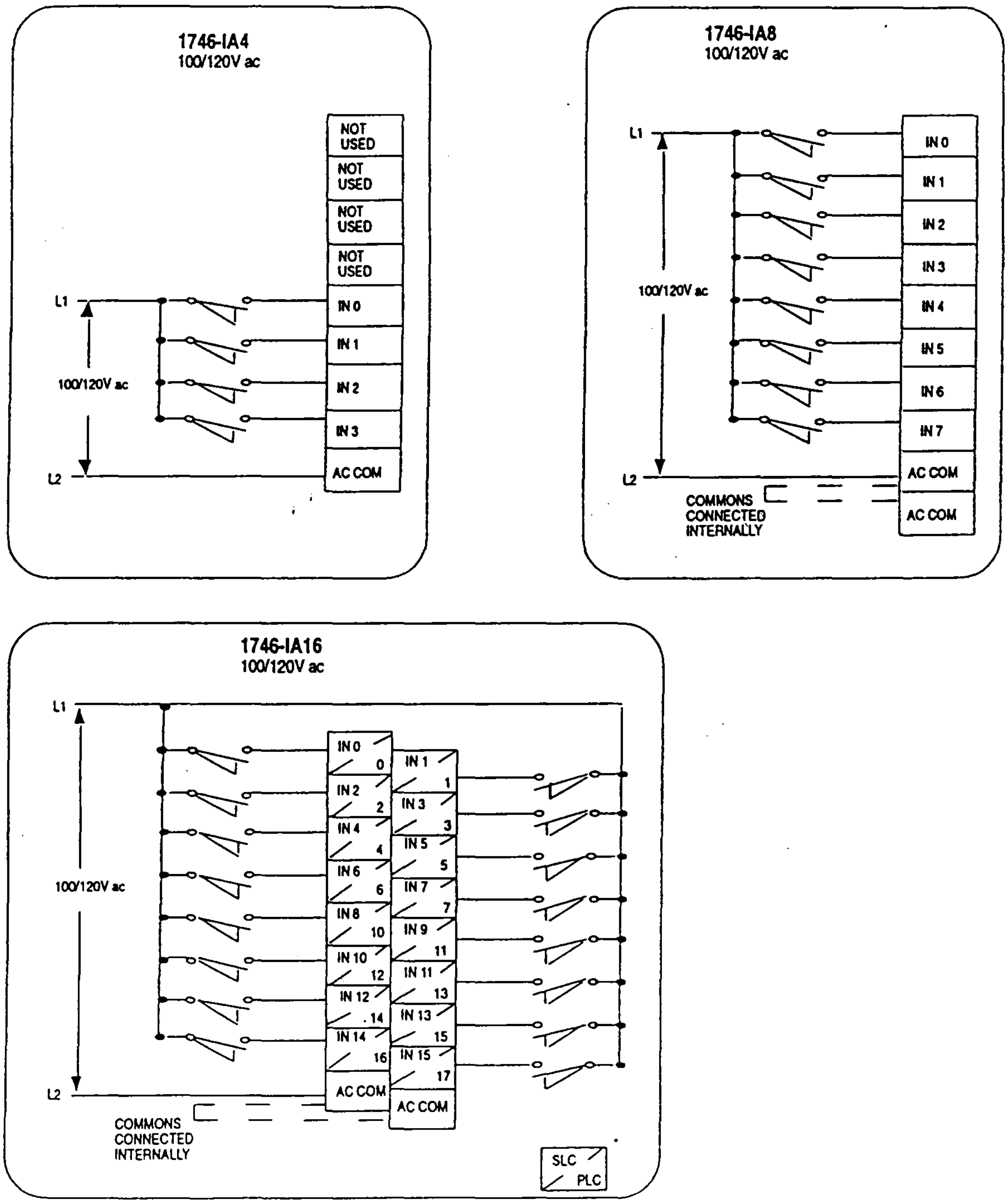
Figure 6
Decimal and Octal Labeling for 16 Point I/O



Wiring Diagrams

Input Modules – ac

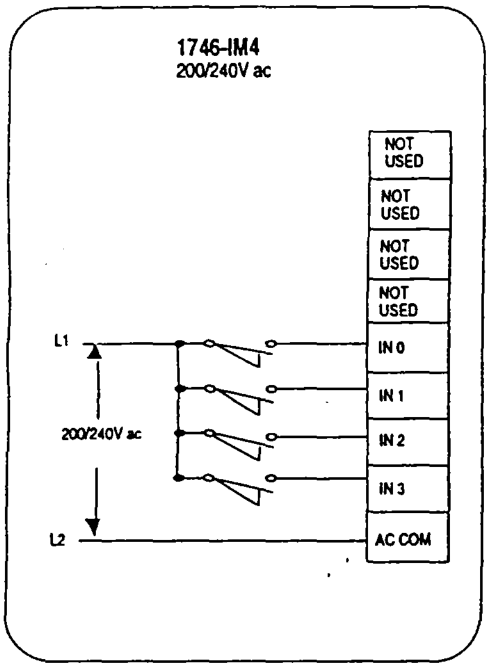
Figure 7
Wiring Diagrams (1746-IA4, -IA8, -IA16)

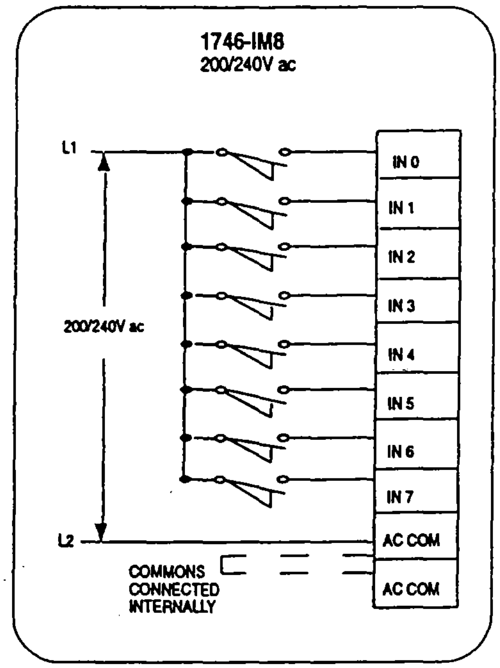


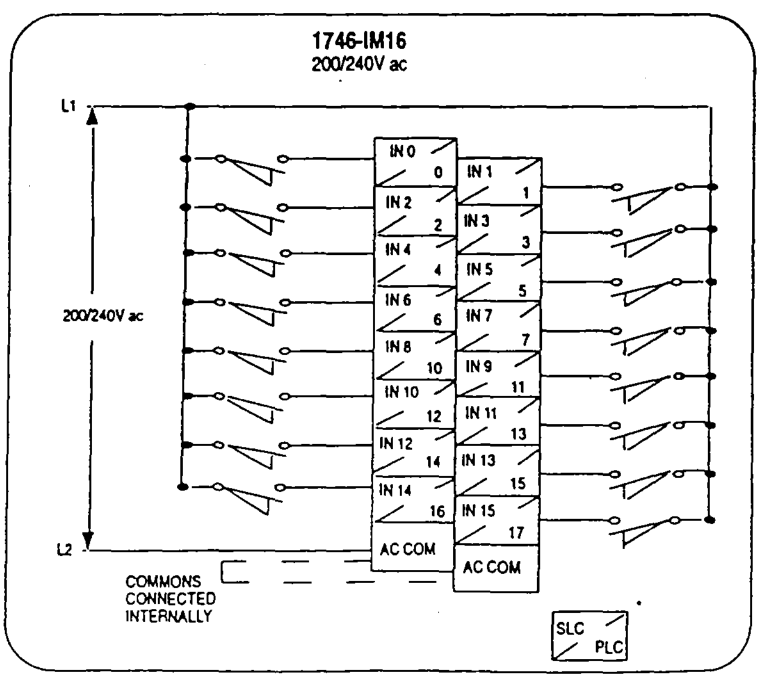
Wiring Diagrams

Input Modules – ac (continued)

Figure 8
Wiring Diagrams (1746-IM4, -IM8, -IM16)







Wiring Diagrams

Input Modules – dc

Figure 9
Wiring Diagram (1746-IN16)

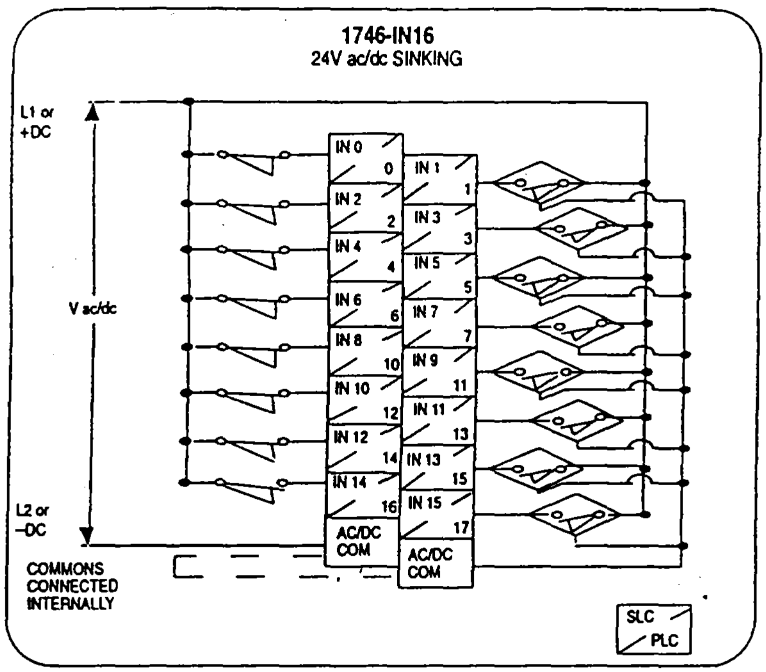
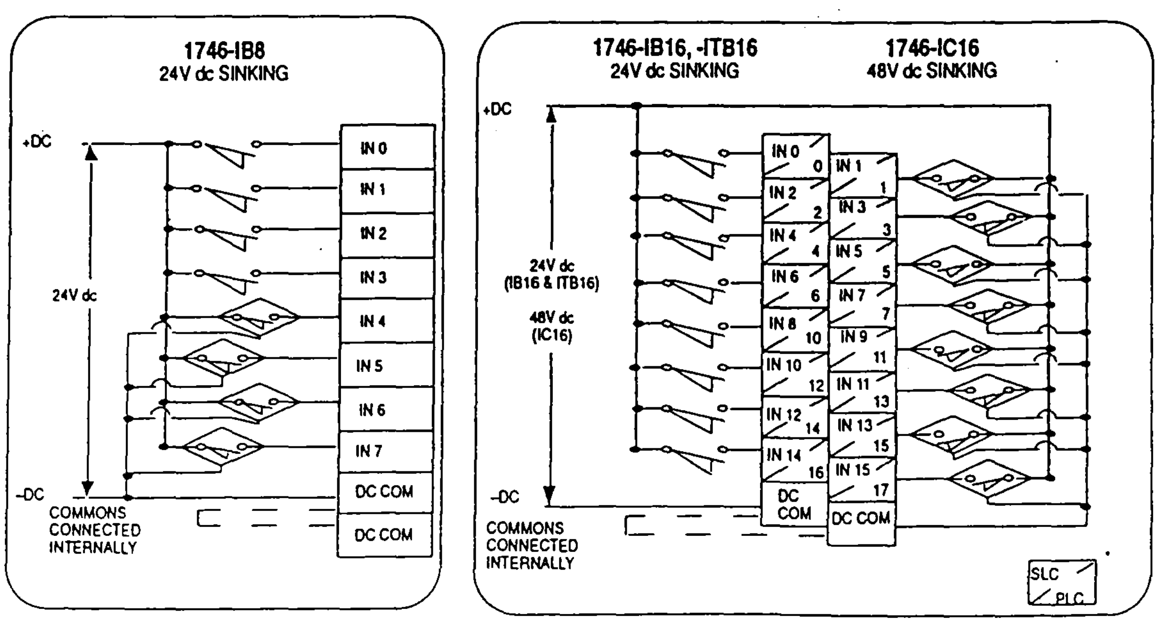


Figure 10
Wiring Diagram (1746-IB8, -IB16, -ITB16, -IC16)



Wiring Diagrams

Input Modules – dc (continued)

Figure 11
Wiring Diagram (1746-IV8, -IV16, -ITV16)

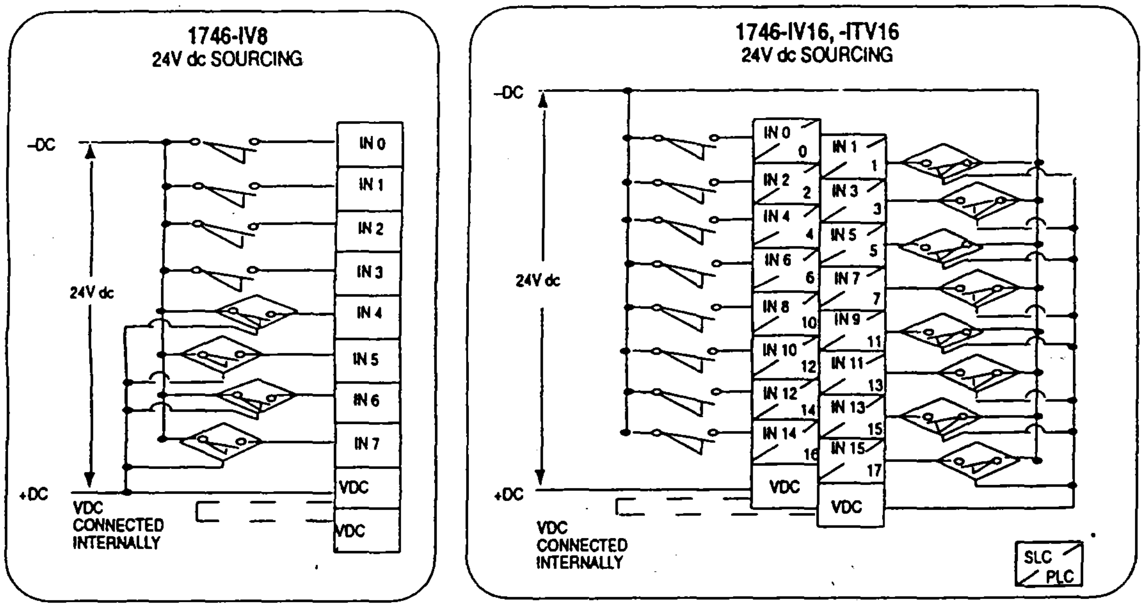
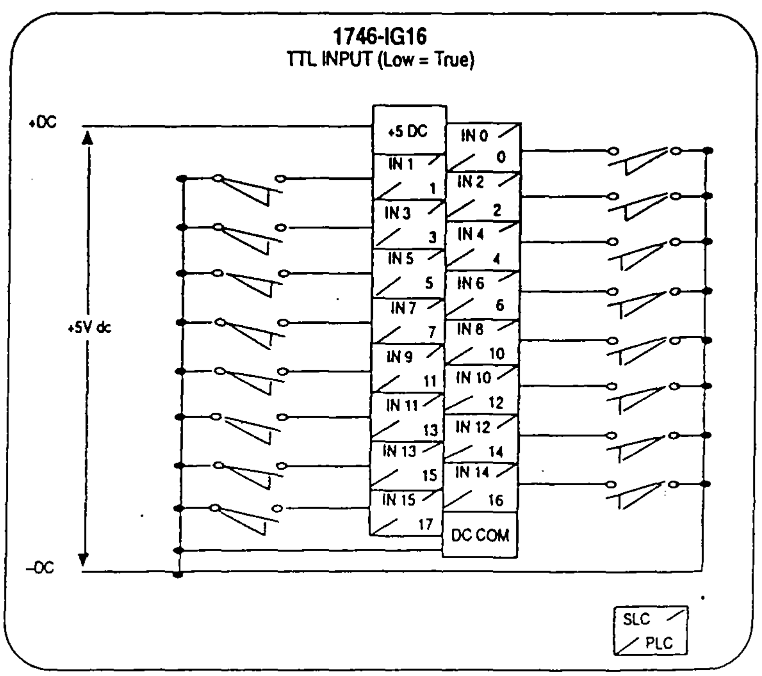


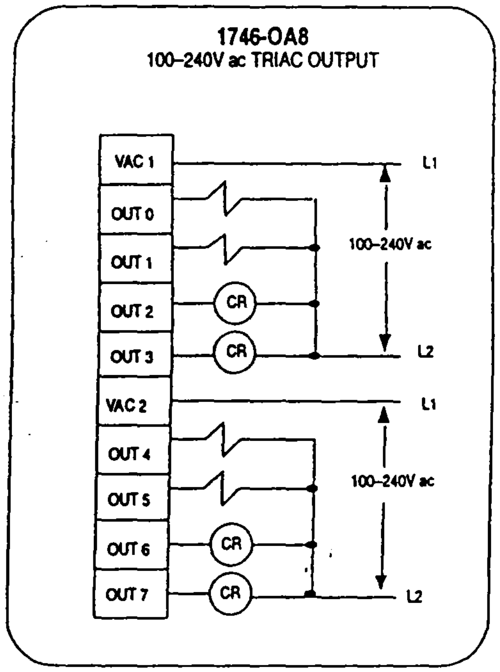
Figure 12
Wiring Diagram (1746-IG16)

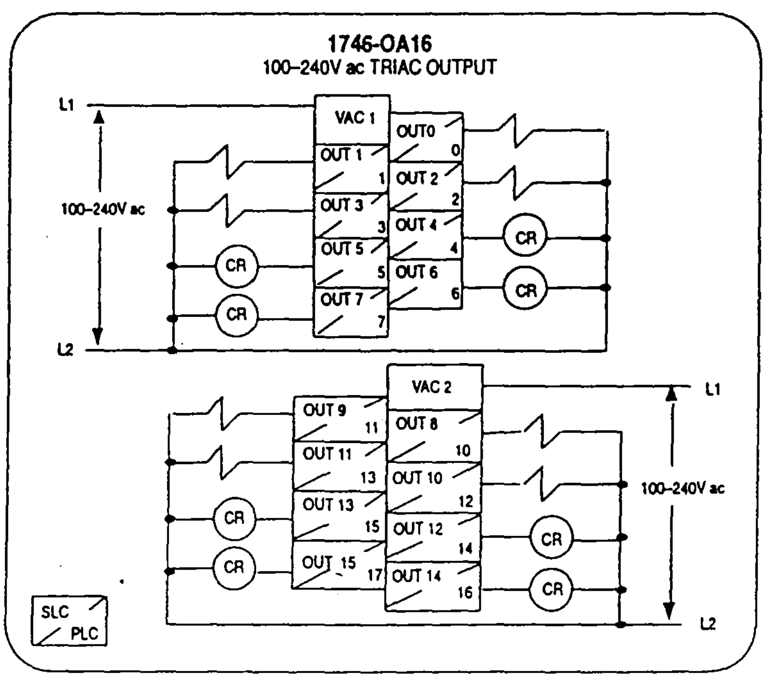


Wiring Diagrams

Output Modules – ac

Figure 13
Wiring Diagrams (1746-OA8, -OA16)

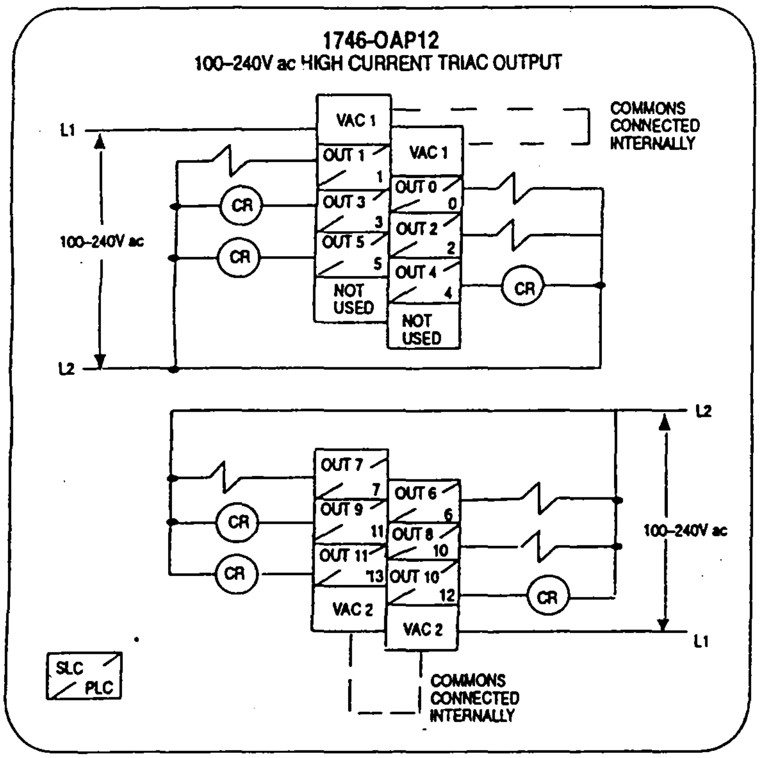




Wiring Diagrams

Output Modules – ac (continued)

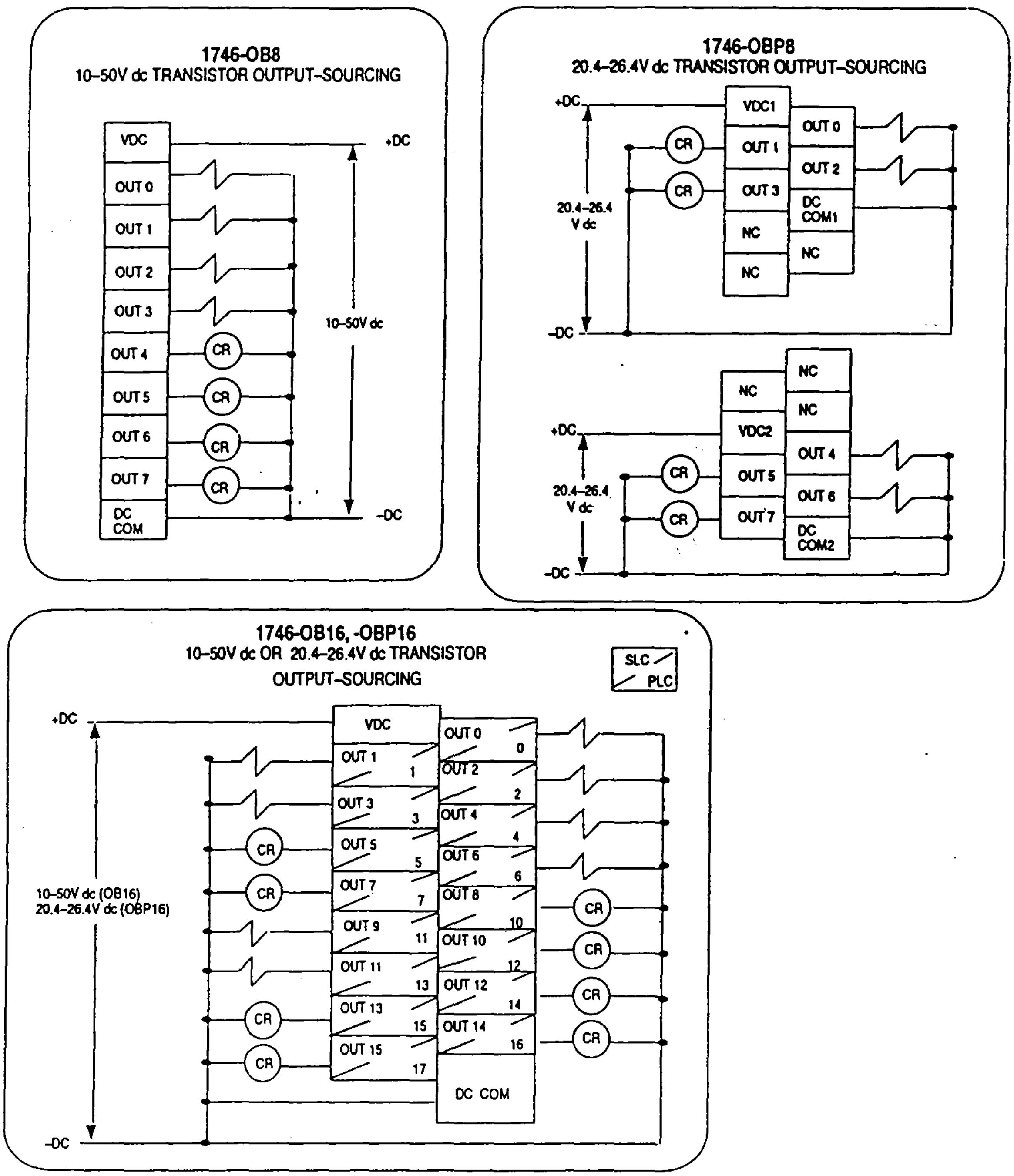
Figure 14
Wiring Diagram (1746-OAP12)



Wiring Diagrams

Output Modules – dc

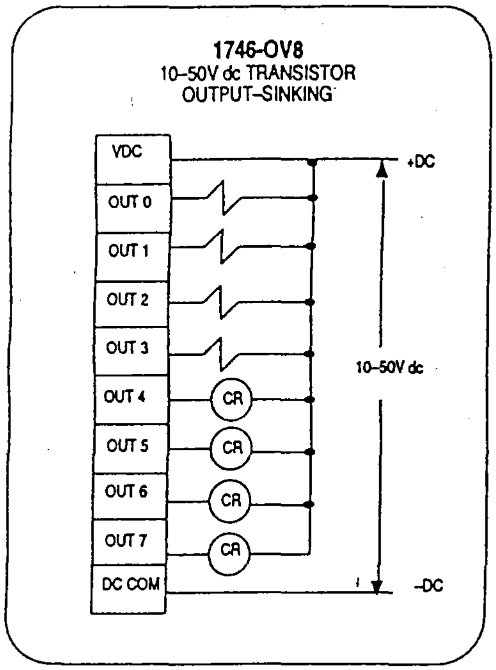
Figure 15
Wiring Diagrams (1746-OB8, -OBP8, -OB16, -OBP16)

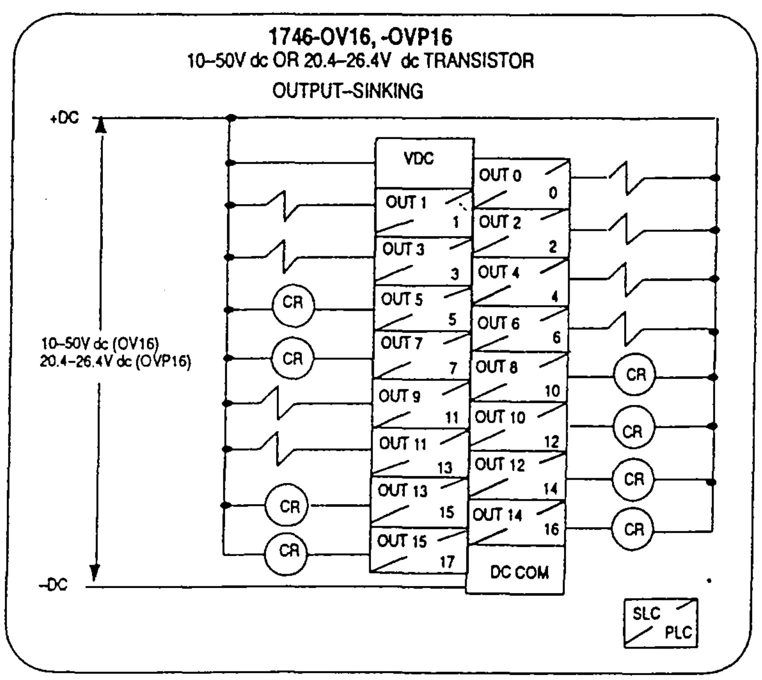


Wiring Diagrams

Output Modules – dc (continued)

Figure 16
Wiring Diagrams (1746-OV8, -OV16, -OVP16)

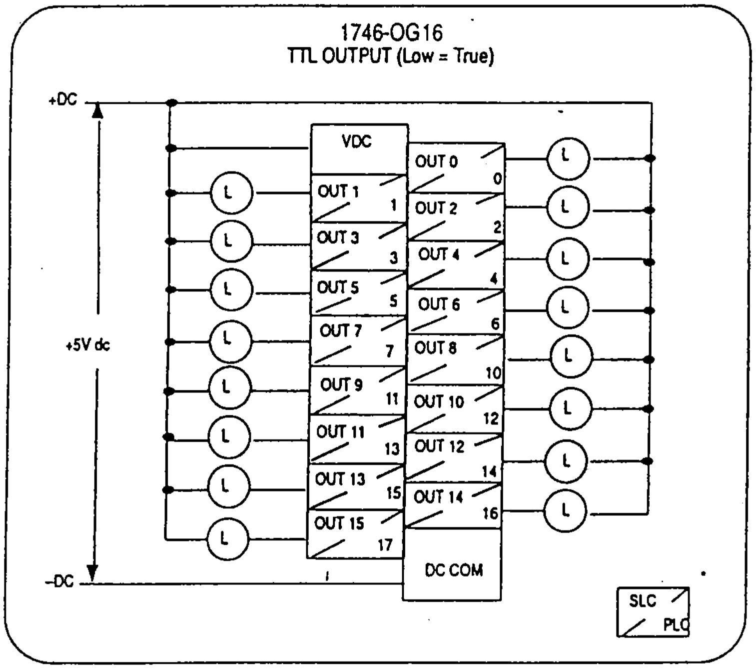




Wiring Diagrams

Output Modules – dc (continued)

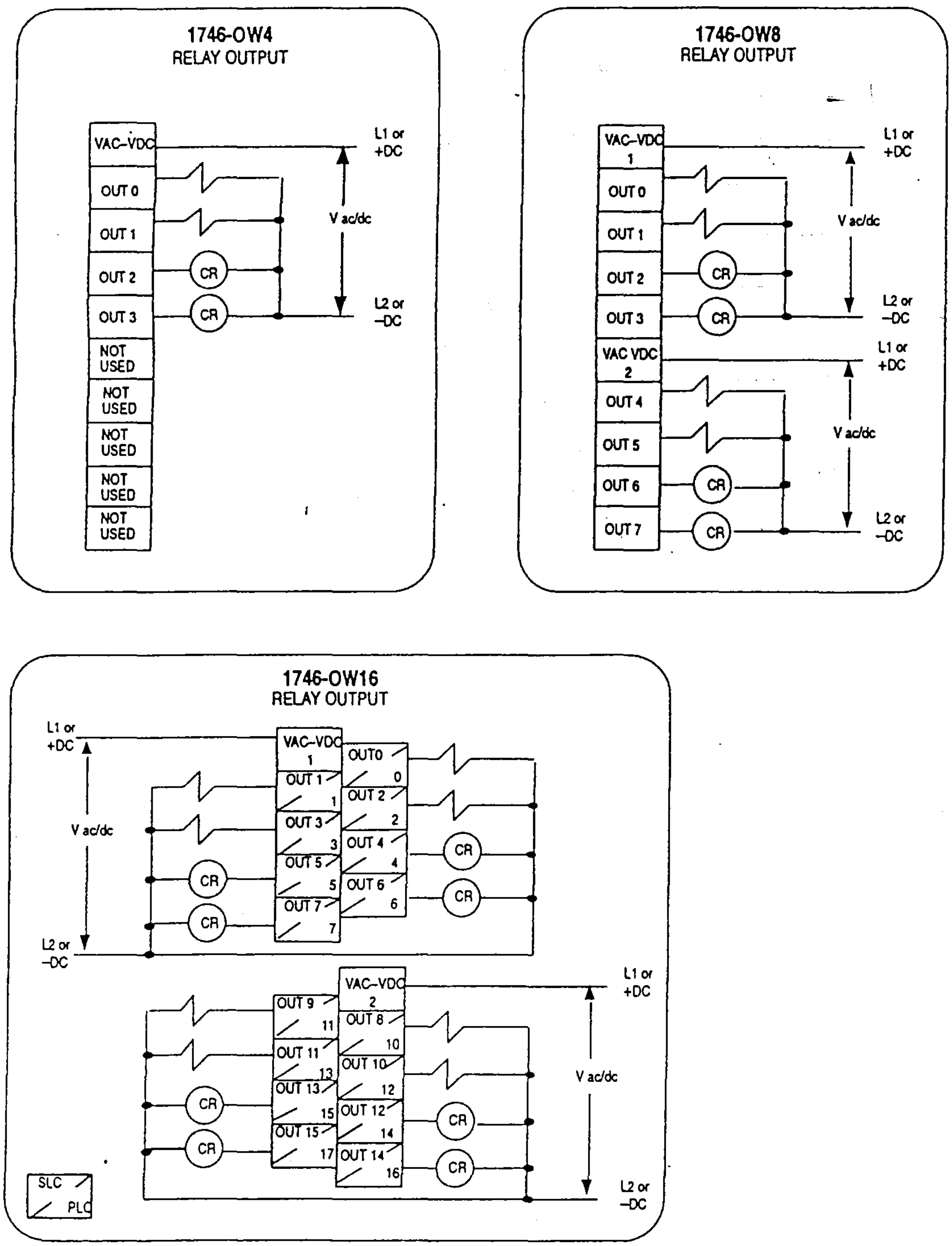
Figure 17
Wiring Diagrams (1746 -OG16)



Wiring Diagrams

Relay Contact Output Modules

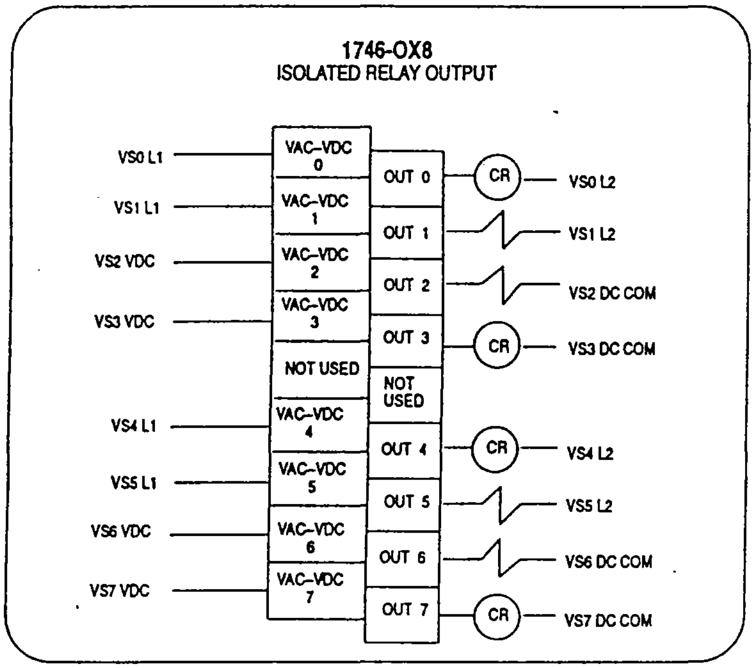
Figure 18
Wiring Diagrams (1746 -OW4, -OW8, -OW16)



Wiring Diagrams

Relay Contact Output Modules (continued)

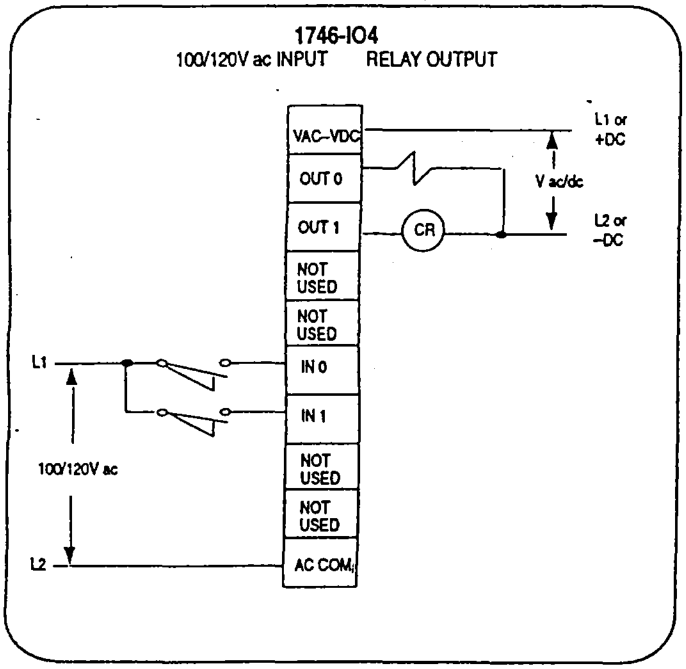
Figure 19
Wiring Diagram (1746-OX8)

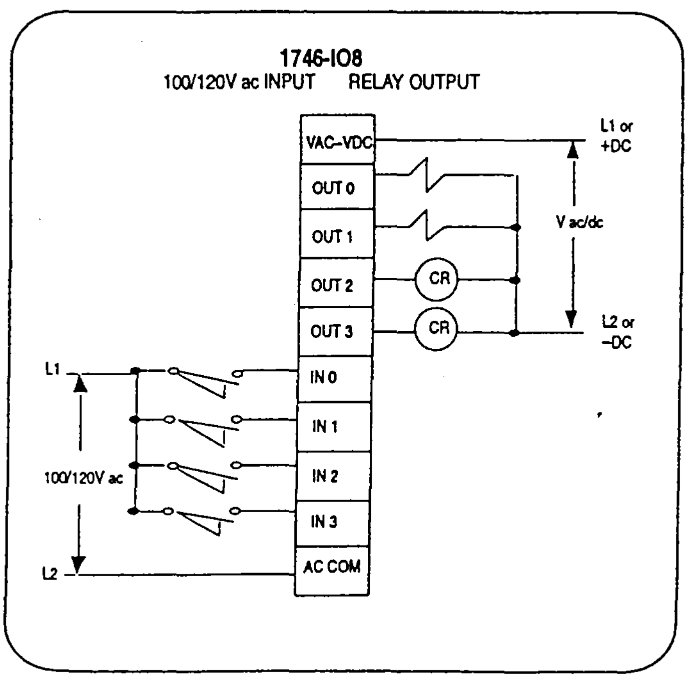


Wiring Diagrams

Input/Output Combination Modules

Figure 20
Wiring Diagram (1746-IO4, -IO8)

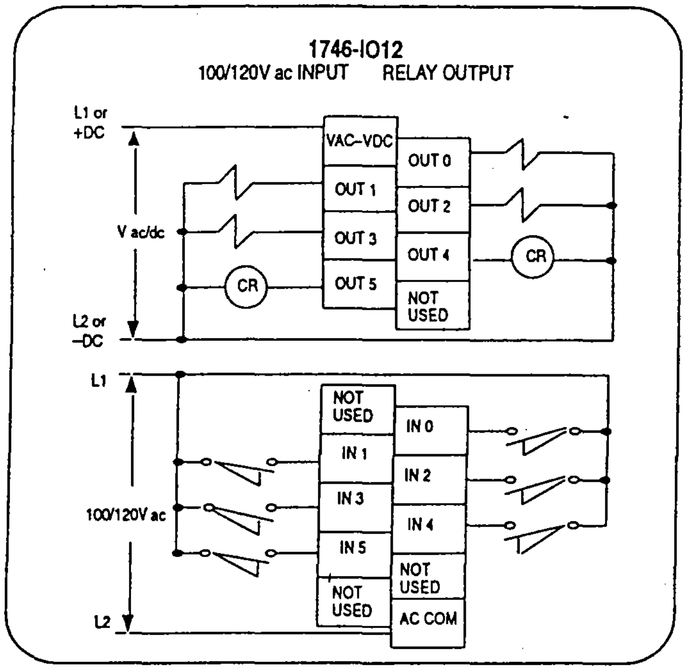




Wiring Diagrams

Input/Output Combination Modules (continued)

Figure 21
Wiring Diagram (1746-IO12)



Notes

SLC 500™ Modular and Fixed Memory Modules

(Cat. No. 1747–M1, 1747–M2, 1747–M3, 1747–M4, 1747–M11 Series B)

Introduction

Always turn off power to the controller before removing the processor and inserting the memory module. This guards against possible damage to the module and undesired processor faults. Memory modules have connectors that are "keyed" to guard against improper installation.

ATTENTION: To avoid potential damage to the memory modules, handle them by the ends of the carrier or edges of the plastic housing. Skin oil and dirt can corrode metallic surfaces, inhibiting electrical contact. Also, do not expose memory modules to surfaces or areas that may typically hold an electrostatic charge. Electrostatic charges can alter or destroy memory.

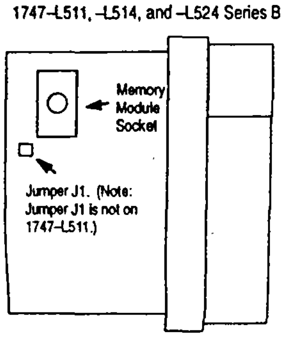
Memory Module Compatibility

Memory Module:	Fixed and 1747–L511:	1747–L514 and –L524 Series B:	1747–L524 Series C:	1747–L532 Series C:	1747–L542:
M1	•	•	•		
M2	•	•	•		
M3	•	•	•		
M4		•	•		
M11				•	•

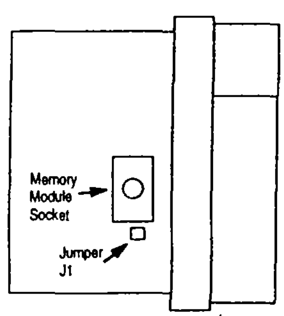
Memory Module Installation

Modular Controller

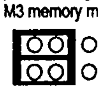
Side View of SLC Processor
1747–L511, –L514, and –L524 Series B



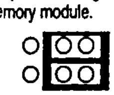
Side View of SLC Processor
1747–L524 Series C



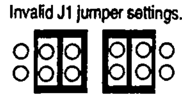
Jumper J1 setting for M1, M2, and M3 memory module.



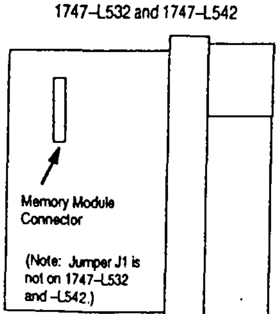
Jumper J1 setting for M4 memory module.



Invalid J1 jumper settings.



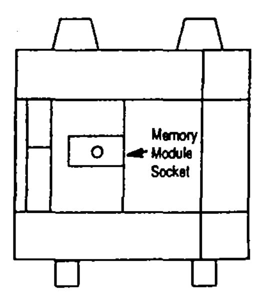
Side View of SLC Processor
1747–L532 and 1747–L542



1. If the processor module is installed in the chassis, turn off power to the controller.
2. Remove the module by pressing the retainer clips at both the top and bottom of the module and sliding it out.
3. Locate the socket on the 1747–L511, –L514, and –L524 processor boards or the connector on the 1747–L532 and –L542 processor boards. Place the memory module onto the socket or connector and press firmly in place.
4. Place jumper J1 as shown above.
5. Install the processor module into the chassis.
6. Restore power to the controller.

Fixed Controller

Front View of 20 I/O Fixed Controller



1. Turn off power to the controller.
2. Remove the processor compartment cover.
3. Locate the socket on the PC board.
4. Position the module correctly over the socket and press the module firmly into place. (The memory module is keyed for proper installation.)
5. Replace the processor compartment cover.
6. Restore power to the controller.

FORM 670-A

WARRICK CONTROLS

Series 67 Installation & Operation Instructions

TABLE OF CONTENTS

WARRICK CONTROLS, INC. **4237 Normandy Court** **Royal Oak, MI 48073**

PH: 810-549-4900 / FAX: 810-549-4904

Series 67
Intrinsically Safe Multi-Function Control
Installation Instructions

WARRICK CONTROLS

Installation: Intrinsically Safe Sensing Circuits

This bulletin should be used by experienced personnel as a guide to the installation of the Series 67 intrinsically safe control. Selection or installation of equipment should always be accompanied by competent technical assistance. We encourage you to contact Warrick or its local representative if further information is required.

IMPORTANT: BEFORE PROCEEDING TO INSTALL AND WIRE THE SERIES 67, READ AND THOROUGHLY UNDERSTAND THESE INSTRUCTIONS.

When installed according to these instructions, this device provides intrinsically safe sensing circuits for interface into Class I, II and III, Division I, Groups C, D, E, F, and G Hazardous locations.
Electrical equipment connected to the Series 67 control should not exceed ratings marked on control.

MOUNTING LOCATION:

The control must be situated in a non-hazardous area where an explosive atmosphere will not exist at any time unless it is mounted in a suitable U.L. approved explosion-proof enclosure with suitable U.L. approved explosion-proof seals.

WIRING: GENERAL INFORMATION

1. Intrinsically safe wiring must be kept separate from non-intrinsically safe wiring.
2. Intrinsically safe and non-intrinsically safe wiring may occupy the same raceway if they are at least 2 inches (50mm) apart and separately tied down. Inside panels, field wiring terminals for intrinsically safe circuits must be separated by at least 2 inches (50mm) from non-intrinsically safe wiring.
3. Wire the control devices to the Series 67 control as shown in FIG. 6-1. A separate rigid metallic conduit must be used to enclose the conductors of the intrinsically safe control circuit.
4. An approved seal should be used at the point where the intrinsically safe control circuit wiring enters the hazardous area.

For intrinsically safe output wiring use #14 or #16 AWG type MTW or THHN wire. By using these wire types in conjunction with the following distance recommendations, you will not exceed the maximum capacitance or inductance for field wiring. Use the following chart **Fig 1 - 1** as a guide for maximum wire runs.

FIG. 1 - 1

MODEL NUMBER	SENSITIVITY	DISTANCE
67AXXXA	4.7 K Ohms	4000 Feet
67BXXXA	10 K Ohms	2400 Feet
67CXXXA	26 K Ohms	1200 Feet
67DXXXA	50 K Ohms	600 Feet
67EXXXA	100 K Ohms	300 Feet

Installation: Intrinsically Safe Circuits (cont.)

GENERAL INFORMATION: (cont.)

GROUNDING:

The four mounting holes on the Series 67 provide an electrical connection for earth grounding between the control's internal solid state circuitry and the enclosure chassis. To insure proper grounding, use only 6/32 metal screws and lock washers when mounting the control. Terminal G on the supply line/load side terminal strip is a redundant system ground terminal and **must be connected to the earth ground buss of the control's AC supply line feeder.**

NOTE:

1. Intrinsically safe terminals can be connected to any non-energy generating or storing device such as a pushbutton, limit or float type switch or any Warrick electrode/fitting assembly.
2. To prevent electrical shock from supply line/load side powered connections, the Series 67 should be mounted in a tool accessible enclosure of proper NEMA rated integrity.
3. For U.L. 913 Listed panels, a metallic partition may be necessary to provide adequate spacing between non-intrinsically safe and intrinsically safe wiring and/or terminals.
4. For additional guidance on "Hazardous Location Installations" and "Intrinsically Safe Devices", consult ANSI/ISA standard RP 12-6 or NEC articles 500 through 516 and other local codes.

SENSOR WIRING:

The Series 67 control has four independent intrinsically safe channels, which can be connected to different types of sensors, including floats, conductance probes, pressure switches and other non-powered contacts or sensors. The connections of the sensor to the terminals will not vary with normally open or closed sensors. However, the Inverse/Direct dip switchs must be set to the proper mode for each channel to achieve the correct operation. Consult TABLES 2 - 1 & 3 - 1 for the proper dip switch settings for various sensors and functions.

The following sections cover the intrinsically safe sensor connections for single and differential level service.

SINGLE LEVEL SERVICE:

All four channels can be used for single level service. Each channel is independent and can be used for its own single point function. However, only channels 3 & 4 have the alarm bell and silence capabilities. Consult the alarm sections for more information regarding the installation & operation of the alarm circuitry. The following TABLE 2 - 1 covers the sensor style to terminal connections for all four channels.

TABLE 2 - 1

SENSOR STYLE	TERMINAL CONNECTIONS	DIP SWITCH SETTING
Normally Open - Closes on alarm condition	Channel 1 -- HS1 & G* Channel 2 -- HS2 & G* Channel 3 -- S3 & G Channel 4 -- S4 & G	Inverse Mode - Up Position
Normally Open - Opens on alarm condition	Channel 1 -- HS1 & G* Channel 2 -- HS2 & G* Channel 3 -- S3 & G Channel 4 -- S4 & G	Direct Mode - Down Position
Normally Closed - Closes on alarm condition	Channel 1 -- HS1 & G* Channel 2 -- HS2 & G* Channel 3 -- S3 & G Channel 4 -- S4 & G	Inverse Mode - Up Position
Normally Closed - Opens on alarm condition	Channel 1 -- HS1 & G* Channel 2 -- HS2 & G* Channel 3 -- S3 & G Channel 4 -- S4 & G	Direct Mode - Down Position

*Note: Channels 1 & 2 can not activate the alarm bell contacts and do not have the silence/acknowledge capabilities

DIFFERENTIAL LEVEL SERVICE

Channels 1 & 2 are designed to provide differential on/off points to control pumps, solenoid valves or other equipment. These channels can also be used in single level service for alarms and cutoffs, however, the control's built in silence circuitry and bell contacts cannot be used. Consult the Alarm section for more information.

When channels 1 & 2 are used for differential level service the associated sensors MUST BE NORMALLY OPEN! The Inverse/Direct dip switchs must also be set to the proper mode for each channel, to achieve the correct operation. The following chart TABLE 3 - 1 gives the correct sensor to terminal connections and dip switch settings for various applications.

FOR APPLICATIONS THAT DO NOT REQUIRE DUPLEX ALTERNATION, A JUMPER WIRE MUST BE PLACED FROM THE "G" TO "1-2" TERMINAL.

TABLE 3 - 1

APPLICATION	SENSOR CONTACT STYLE	SENSOR TERMINAL CONNECTIONS	DIP SWITCH SETTING
Simplex Pump Down or Solenoid Valve Drain**	Normally Open - Closes on Rising Level	Start Pump/Open Valve-- HS1 & G* Stop Pump/Close Valve -- LS1 & G*	Direct - DOWN Channels 1 or 2
Simplex Pump Up or Solenoid Valve Fill**	Normally Open - Closes on Rising Level	Start Pump/Open Valve-- LS1 & G* Stop Pump/Close Valve -- HS1 & G*	Inverse - UP Channels 1 or 2
Duplex Pump Down - Common Pump Stop	Normally Open - Closes on Rising Level	Duty Pump Start -- HS1 & G* Standby Pump Start -- HS2 & G* Duty and Standby Pump Stop - LS1 & G* Jumper LS1 & LS2	Direct - DOWN Channels 1 & 2
Duplex Pump Up - Common Pump Stop	Normally Open - Closes on Rising Level	Duty Pump Start -- LS1 & G* Standby Pump Start -- LS2 & G* Duty and Standby Pump Stop - HS1 & G* Jumper HS1 & HS2	Inverse - UP Channels 1 & 2
Duplex Pump Down - Seperate Pump Stops	Normally Open - Closes on Rising Level	Duty Pump Start -- HS1 & G* Standby Pump Start -- HS2 & G* Duty Pump Stop -- LS1 & G* Standby Pump Stop -- LS2 & G*	Direct - DOWN Channels 1 & 2
Duplex Pump Up - Seperate Pump Stops	Normally Open - Closes on Rising Level	Duty Pump Start -- LS1 & G* Standby Pump Start -- LS2 & G* Duty Pump Stop -- HS1 & G* Standby Pump Stop -- HS2 & G*	Inverse - UP Channels 1 & 2

*NOTE-1: If conductance probes are being used only one G connection is required. Terminal G must be grounded to the vessel if metallic. If the electrode fitting being used has a metallic body and is supported directly upon a metallic vessel, the ground connection is facilitated by securing that end of the ground connector beneath the head of one of the screws which fasten the terminal housing to the body of the fitting. When the vessel is non-metallic, terminal G must be connected to an additional electrode of length equal to or longer than, the longest electrode. If wire suspended electrodes are being used, more than one Ground/Reference probe may be required.

**NOTE-2: This setup based on the use of a Normally closed (N.C.) solenoid valve that energizes to open when power is applied to the coil circuit.

Installation: Intrinsically Safe Circuits (cont.)

ALARM CHANNEL WIRING:

SILENCE CIRCUITRY:

A normally open pushbutton is required to operate the Series 67's alarm silence circuitry. The N.O. pushbutton must be connected to the SIL & G Terminals. For more information about the operation of the silence circuitry consult the Alarm Operation section on page 9. NOTE: THE SILENCE PUSHBUTTON IS CONNECTED TO INTRINSICALLY SAFE CIRCUITRY. THEREFORE THE PUSHBUTTON AND ITS ASSOCIATED WIRING SHOULD BE SEPARATED FROM NON-INTRINSICALLY SAFE WIRING AND DEVICES. CONSULT PAGE 1 FOR MORE INFORMATION.

ALARM DIP SWITCHES:

The alarm dipswitches for channels 3 & 4 can be set to enable the bell contacts for one or both alarm channels. However, this does not disable the alarm contact for that channel. The following TABLE 4 - 1 covers the dip switch settings for various alarm conditions.

TABLE 4 - 1

DIP SWITCH SETTING	BELL CONTACT STATUS
3 Off - Down 4 Off - Down	Channel 3 - Off - Disabled Channel 4 - Off - Disabled
3 On - Up 4 Off - Down	Channel 3 - On - Enabled Channel 4 - Off - Disabled
3 On - Up 4 On - Up	Channel 3 - On - Enabled Channel 4 - On - Enabled
3 Off - Down 4 On - Up	Channel 3 - Off - Disabled Channel 4 - On - Enabled

ALTERNATION CIRCUITRY:

AUTO OR MANUAL:

The Series 67 control's built in alternator can be used to automatically alternate between two loads controlled by channels 1 & 2. However, the automatic alternation may be bypassed to become a manual operation. This can be accomplished with the use of jumper wires or a three position switch connected to the 2-1, 1-2 and G terminals. The following TABLE 4 - 2 covers the jumper connections for the manual alternation. Refer to the FIG. 6 - 1 for more wiring information on the wiring of the three position selector switch. NOTE: THE MANUAL ALTERNATION CIRCUITRY IS CONSIDERED INTRINSICALLY SAFE. THEREFORE THE SELECTOR SWITCH, JUMPER WIRES AND THEIR ASSOCIATED WIRING SHOULD BE SEPARATED FROM NON-INTRINSICALLY WIRING DEVICES. CONSULT PAGE 1 FOR MORE INFORMATION ON INTRINSIC SAFETY.

TABLE 4 - 2

ALTERNATION STATUS	JUMPER REQUIRED	LED STATUS PUMP DOWN*	LED STATUS PUMP UP*
Automatic *	None	Either	Either
Manual 1 - 2	Terminals 1 - 2 to G	No. 1**	No. 1**
Manual 2 - 1*	Terminals 2 - 1 to	No. 2**	No. 2**

* NOTE: – For Non-alternation applications jumper 1–2 to G.

** NOTE – The position of the 1–2, 2–1 indicating LED's is dependent on the application. The position changes for pump up or down. Consult Control Diagram FIG. 6–1 for more information.

Installation: High Voltage Circuits

A.C. SUPPLY:

Connect the incoming supply HOT lead to the L1 terminal, NEUTRAL lead to the L2 terminal and EARTH GROUND lead to the G terminal. NOTE: The incoming power supply should have the same electrical characteristics as indicated on the control's label.

GROUNDING:

Terminal G on the supply line/load side terminal strip is a redundant system ground terminal and **must be connected to the earth ground buss of the panel's AC supply line feeder.**

OUTPUT CONTACTS:

Channels 1 - 4: Each channel has dedicated non-powered contacts. These can be either Form C or Form A & B contacts depending on the model. These contacts will change state when their respective channel activates. In DIRECT mode the relay will energize and the contacts will change state when the probe circuit sensor closes. In INVERSE mode the relay will energize and contacts will change state upon power up . The channel will then de-energize and return the contacts to their shelf state when the probe circuit sensor closes.

Form C - This contact configuration consists of (1) Normally Open contact and (1) Normally Closed contact. There are three terminals for electrical connections, N.O., N.C. and Common. Each terminal will accept up to (2) - 14 AWG wires.

Form A & B: This contact configuration consists of (1) Normally Open contact and (1) Normally Closed contact which are electrically isolated from each other. There are two terminals for each contact. Each terminal will accept (1) - 14 AWG wire.

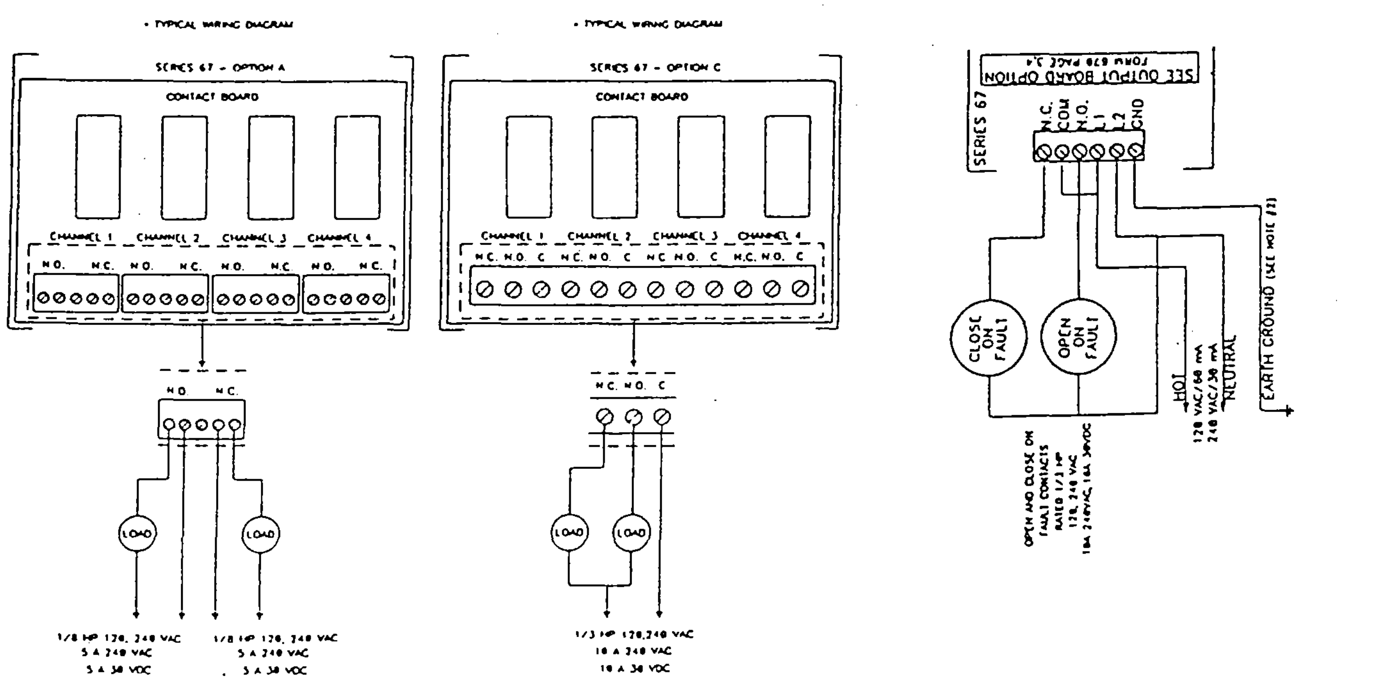
Alarm Bell: The alarm bell contacts are non-powered and of Form C construction. This contact configuration consists of (1) Normally Open contact and (1) Normally Closed contact. There are three terminals for electrical connections, N.O., N.C. and Common. Each terminal will accept up to (2) - 14 AWG wires.

When the output contacts are used to drive loads they should be wired in series with the load. This series branch circuit should then be connected across a power source compatible with the load. See diagrams below.

Load Contacts

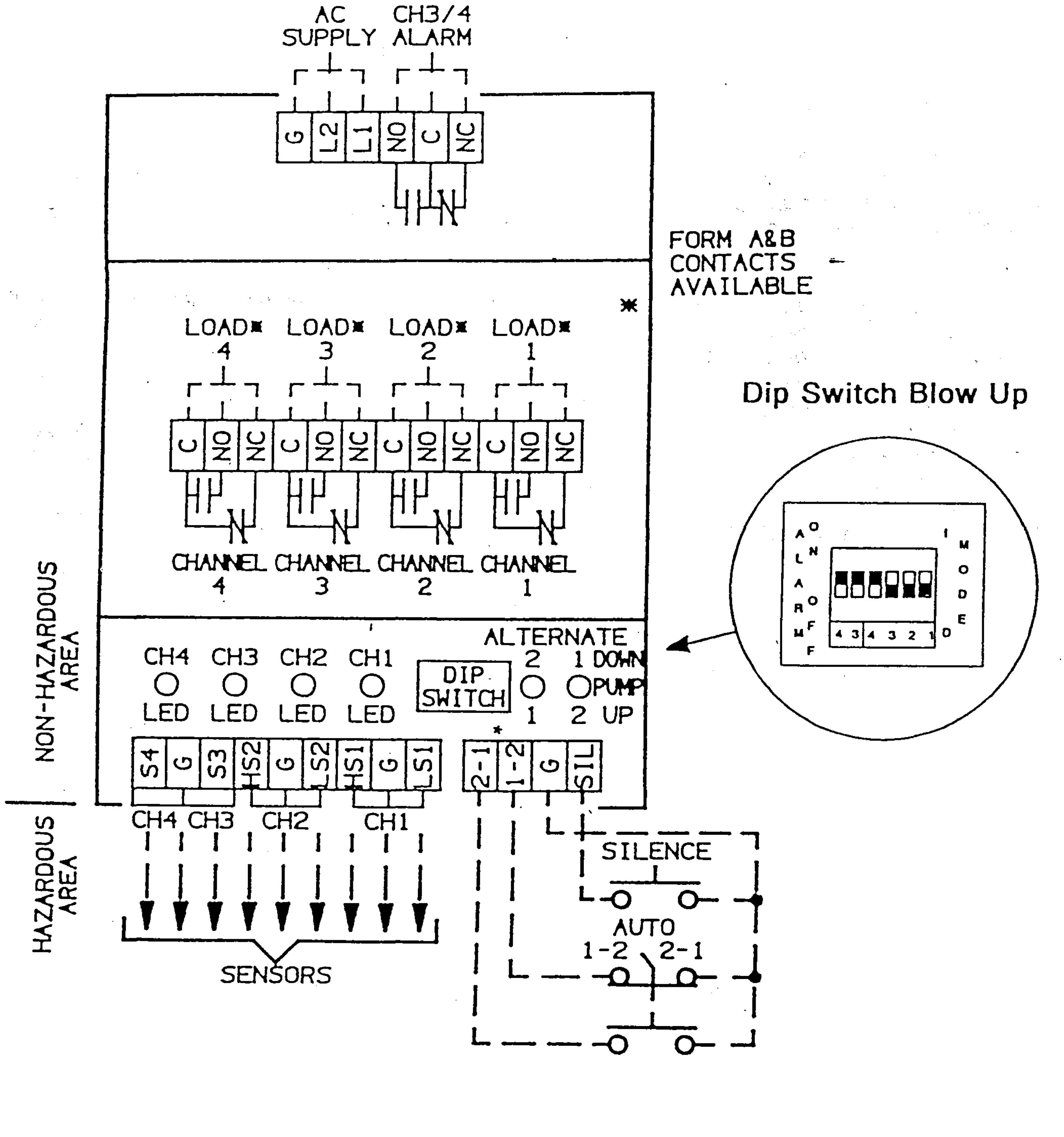
FIG. 5 - 1

Alarm Bell Contacts



CONTROL DIAGRAM:

FIG. 6 - 1



*NOTE FOR APPLICATIONS THAT DO NOT REQUIRE DUPLEX ALTERNATION, A JUMPER WIRE MUST BE PLACED FROM THE "G" TO "1–2" TERMINAL.

Technical Information

SPECIFICATIONS:

Load Contacts: Standard - 1 Form C (N.O., N.C., C.) for each channel. Optional - 1 Form A (N.O.) and 1 Form B (N.C.) isolated.
Bell Contacts: 1 Form C (N.O., N.C., C.)
Load Contact Ratings: Standard Form C - 10A @ 120/240 VAC and 30VDC Resistive, 1/3 HP @ 120/240 VAC
Optional Form A & B - 5A @ 120/240 VAC and 30VDC Resistive, 1/8 HP @ 120/240VAC.
Bell Contact Ratings: 10A @ 120/240 VAC and 30VDC resistive, 1/3 HP @ 120/240 VAC.
Contact Life: Electrical @ rated load = 1,000,000 cycles minimum. Mechanical = 10,000,000 cycles.
Primary (A.C. Supply Line):
(a) Voltage: 120,240 VAC, plus 10%, minus 15%
(b) Frequency: 50/60 Hertz
(c) Power: Relay Energized, 60ma @ 120VAC, 30ma @ 240VAC.
Secondary (probe circuit): Nominal - 12VAC @ 6ma RMS
Senstivity Range: 4700 - 100,000 Ohms maximum specific resistance.
Temperature Rating: (minus) -40 deg. F. to (plus) +150 deg. F.
Electronics Module: Solid state components enclosed in a molded nylon housing.
Terminals: Standard Form C removable terminal strip, contains a size 4 pan head screw with a clamping plate. Will accept up to (2) - 14 AWG wires. Optional Form A & B relay board will accept up to (1) 14 AWG wire per terminal. USE COPPER (60/75 DEGREE C) WIRE ONLY. TORQUE TO 20 INCH-POUNDS.
Listing: U.L. 913 - Process Control Equipment Associated Apparatus with Intrinsically Safe Output. Class I, II and III,

ORDERING INFORMATION:

SERIES 67 X X X X A

Optional character

Enclosure 0 - Open
1 - Nema 1

Output Board Contact Type A - 1 Form A & B (N.O. & N.C. Isolated) for each channel
C - 1 Form C (N.O., N.C., Common)

Input Voltage: 1 - 120 VAC
2 - 240VAC

Sensitivity: A - 4.7 K
B - 10 K
C - 26 K
D - 50 K
E - 100 K

MODULE REPLACEMENT:

If the electronic module needs to be replaced, follow the procedure listed below:

1. Turn off power to the control and load devices.

2. Remove the metal partition located across the center of the module (When required).

3. Remove all field wiring terminal blocks from the electronic module. **The field wires do not need to be removed from the terminal blocks.** The terminal blocks separate from the board as shown in FIG. 8 - 1

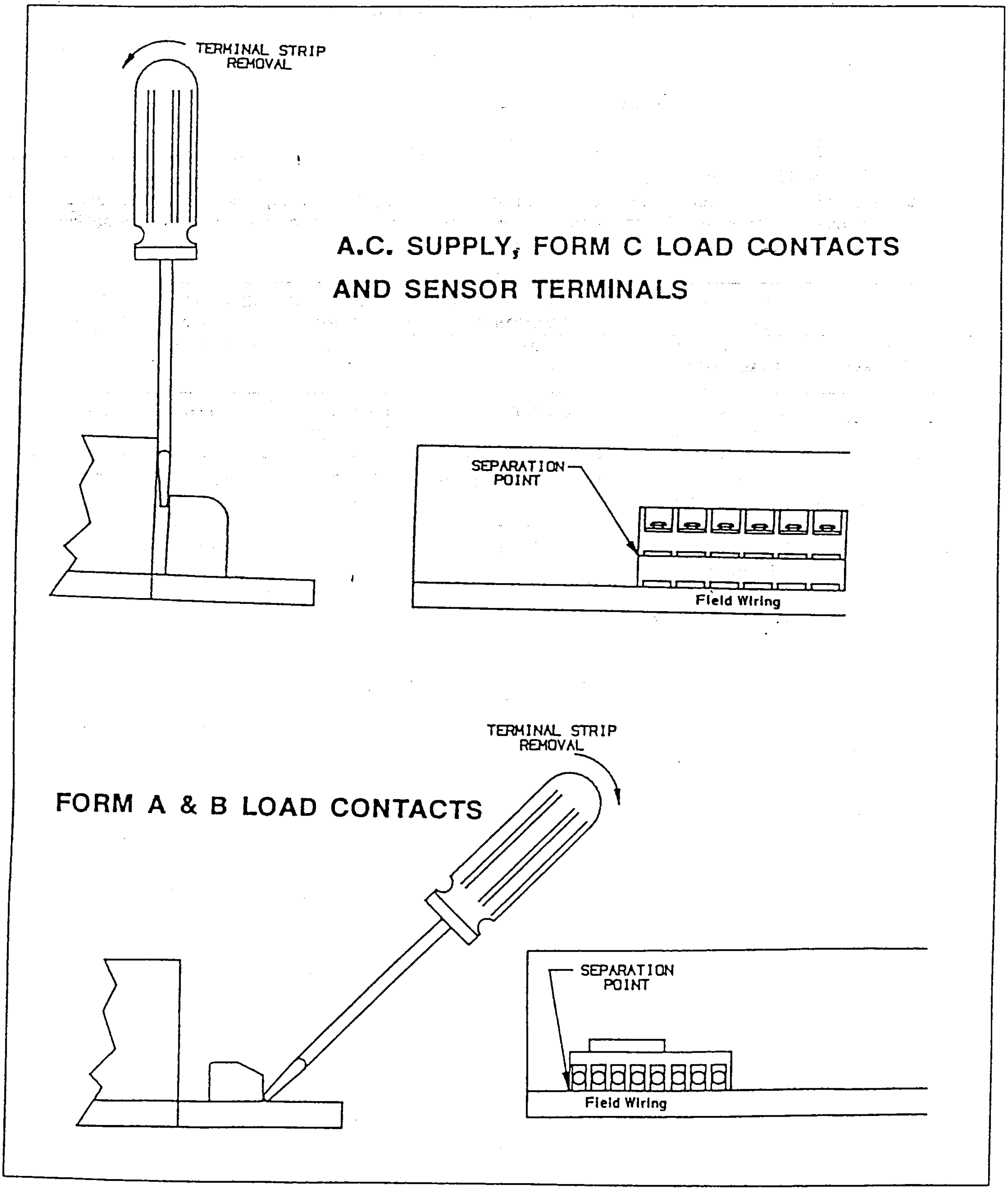
4. Remove the four (4) retaining screws from the base of the electronic module. The module can now be removed from the control panel.

5. Install a new module and reinstall all of the terminal blocks.

6. Reinstall the metal partition (When required).

7. Set all dip switches according to previous instructions.

FIG. 8 - 1


TERMINAL STRIP REMOVAL
A.C. SUPPLY, FORM C LOAD CONTACTS
AND SENSOR TERMINALS
SEPARATION POINT
Field Wiring
TERMINAL STRIP REMOVAL
FORM A & B LOAD CONTACTS
SEPARATION POINT
Field Wiring

OPERATION INSTRUCTIONS

The Series 67 Multi-function control can be used for many different applications including: Pump control, solenoid valve control and alarm activation. The following instructions cover the most common applications. If your application is not included, contact Warrick Controls or our authorized Representative in your area for assistance.

The operating instructions are broken up into two general categories: SINGLE and DIFFERENTIAL LEVEL SERVICE. The alarm functions are covered under the SINGLE LEVEL SERVICE heading while the pumping and solenoid valve functions are covered under the DIFFERENTIAL LEVEL SERVICE heading.

SINGLE LEVEL SERVICE: CONTACT OPERATION

LOAD CONTACTS: CHANNELS 1 - 4

The activation of these contacts is dependent upon the type of sensor (normally open or closed) and the mode of operation (direct or inverse). The following chart gives the sensor activation conditon, dipswitch setting, contact status and LED status for various applications and sensors.

TABLE 9 - 1

APPLICATION	WARRICK SENSOR	SENSOR'S ALARM ACTIVATION CONDITION	DIP SWITCH SETTING	RELAY STATUS UPON ALARM	LED STATUS UPON ALARM
High Level Alarm - Normally Open Float	FE - Reed Switch Float F - Mercury Tilt Float	Closes On Rising Level	INVERSE Up "I"	De-energized	ON
High Level Alarm - Normally Closed Float	FE - Reed Switch Float F - Mercury Tilt Float	Opens On Rising Level	DIRECT Down "D"	De-energized	OFF
Low Level Alarm - Normally Open Float	FE - Reed Switch Float F - Mercury Tilt Float	Opens On Falling Level	DIRECT Down "D"	De-energized	OFF
Low Level Alarm - Normally Closed Float	FE - Reed Switch Float F - Mercury Tilt Float	Closes On Falling Level	INVERSE Up "I"	De-energized	ON
High Level Alarm - Conductance Probes	3R, 3T, 3W, 3Y, 3H AND 3S	Probes In Contact With Conductive Liquid	INVERSE Up "I"	De-energized	ON
Low Level Alarm - ConductanceProbes	3R, 3T, 3W, 3Y, 3H AND 3S	Probes NOT In Contact With Conductive Liquid	DIRECT Down "D"	De-energized	OFF
UNKNOWN SENSOR Normally Open		Closes On Fault	INVERSE Up "I"	De-energized	ON
UNKNOWN SENSOR Normally Closed		Opens On Fault	DIRECT Down "D"	De-energized	OFF

SINGLE LEVEL SERVICE: ALARM FUNCTIONS

BELL CONTACTS:

Under **NORMAL** operating conditions the alarm bell relay is held energized. The relay will de-energize to activate an alarm device when an abnormal condition exists on either channels 3 and/or 4. Either one or both alarm bell circuits can be disabled by adjusting the alarm dip switches. Consult **Fig. 4 - 1** for more information on the alarm bell dip switch settings.

SILENCE CIRCUITRY:

Should an abnormal condition exist on either channels 3 and/or 4 the normally closed (N.C.) alarm bell relay contacts will close, activating an alarm device. The N.C. alarm bell contacts can be returned to their normal state (open) silencing the alarm, by depressing a normally open pushbutton connected to the SIL & G terminals. This will NOT affect the load contacts for channels 3 or 4 as they act independently from the alarm bell contacts.

DIFFERENTIAL LEVEL SERVICE:

The following operating instructions are based on correct dip-switch settings and sensor types. Any deviation from these requirements may result in incorrect system operation. Please consult the following chart

TABLE 10 - 1

APPLICATION	WARRICK SENSOR	DIP SWITCH SETTING	ACTIVATION CONDITION	CONTACT STATUS	LED STATUS SENSOR CLOSED
Simplex Pump Down or Solenoid Valve Drain	Normally Open - F, FE, 3R, 3T, 3W, 3Y, 3H AND 3S	Direct Down	Sensor Closes On Rising Level	N.O. - Closes N.C. - Opens	ON
Simplex Pump Up or Solenoid Valve Fill	Normally Open - F, FE, 3R, 3T, 3W, 3Y, 3H AND 3S	Inverse Up	Sensor Closes On Rising Level	N.O. - Opens N.C. - Closes	OFF
Duplex Pump Down - Common Pump Stop	Normally Open - F, FE, 3R, 3T, 3W, 3Y, 3H AND 3S	Direct Down	Sensor Closes On Rising Level	N.O. - Closes N.C. - Opens	ON
Duplex Pump Up - Common Pump Stop	Normally Open - F, FE, 3R, 3T, 3W, 3Y, 3H AND 3S	Inverse Up	Sensor Closes On Rising Level	N.O. - Opens N.O. - Closes	OFF
Duplex Pump Down - Seperate Pump Stop	Normally Open - F, FE, 3R, 3T, 3W, 3Y, 3H AND 3S	Direct Down	Sensor Closes On Rising Level	N.O. - Closes N.O. - Opens	ON
Duplex Pump Up - Seperate Pump Stop	Normally Open - F, FE, 3R, 3T, 3W, 3Y, 3H AND 3S	Inverse Up	Sensor Closes On Rising Level	N.O. - Opens N.C. - Closes	OFF

DIFFERENTIAL LEVEL SERVICE: SIMPLEX

Simplex Pump Down - Should the level rise to the PUMP START sensor the N.O. load contacts will close starting the pump. The pump will remain running until the level recedes below the PUMP STOP sensor and the load contacts open.

Simplex Pump Up - Should the level recede below the PUMP START sensor the N.O. load contacts will close starting the pump. The pump will remain running until the level rises to the PUMP STOP sensor and the load contacts open.

Solenoid Valve Drain - Should the level rise to the VALVE OPEN sensor, the N.O. load contacts will close energizing the normally closed valve to open. The valve will remain open until the level recedes below the VALVE CLOSE sensor and the load contacts open.

Solenoid Valve Fill - Should the level recede below the VALVE OPEN sensor, the N.O. load contacts will close energizing the normally closed valve to open. The valve will remain open until the level rises to the VALVE CLOSE

DIFFERENTIAL LEVEL SERVICE: DUPLEX PUMP DOWN WITH ALTERNATION

Common Pump Stop - The pumps will alternate each cycle with the duty pump starting when the level rises to the DUTY PUMP START sensor, and stopping when the level recedes below the PUMP(S) STOP sensor.

If the duty pump fails or cannot meet the demand of the system and the level rises to the STANDBY PUMP START sensor, the standby pump will be started and will continue in operation until the level recedes below the PUMP(S) STOP sensor.

Separate Pump Stops - The pumps will alternate each cycle with the duty pump starting when the level rises to the DUTY PUMP START sensor, and stopping when the level recedes below the DUTY PUMP STOP sensor.

If the duty pump fails or cannot meet the demand of the system and the level rises to the STANDBY PUMP START sensor, the standby pump will be started and will continue in operation until the level recedes below the STANDBY PUMP STOP sensor.

DIFFERENTIAL LEVEL SERVICE: DUPLEX PUMP UP WITH ALTERNATION

Common Pump Stop - The pumps will alternate each cycle with the duty pump starting when the level recedes below the DUTY PUMP START sensor, and stopping when the level rises to the PUMP(S) STOP sensor.

If the duty pump fails or cannot meet the demand of the system and the level recedes below the STANDBY PUMP START sensor, the standby pump will be started and will continue in operation until the level rises to the PUMP(S) STOP sensor.

Separate Pump Stops - The pumps will alternate each cycle with the duty pump starting when the level recedes below the DUTY PUMP START sensor, and stopping when the level rises to the DUTY PUMP STOP sensor.

If the duty pump fails or cannot meet the demand of the system and the level recedes below the STANDBY PUMP START sensor, the standby pump will be started and will continue in operation until the level rises to the STANDBY PUMP STOP sensor.

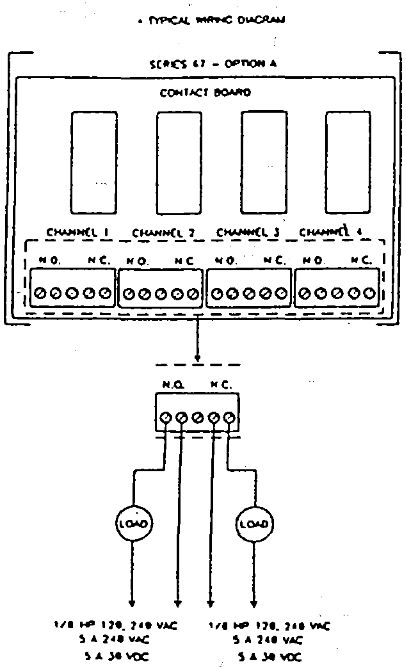
DIFFERENTIAL LEVEL SERVICE: DUPLEX PUMP DOWN WITHOUT ALTERNATION

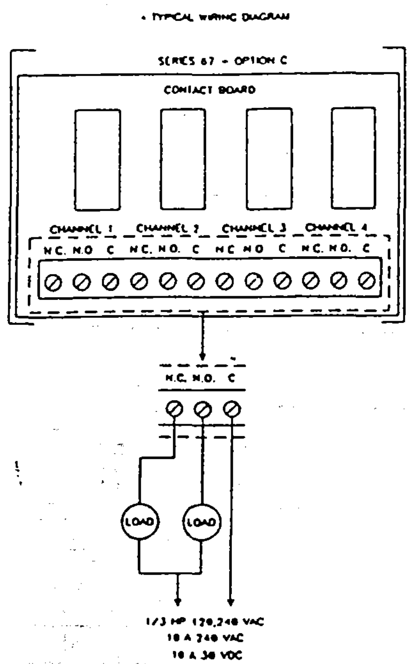
Same operation as above disregarding the alternation sequence.. Use the appropriate jumper to determine manual pump start sequence. Refer to FIG. 4 - 2 for the manual alternation jumper information.

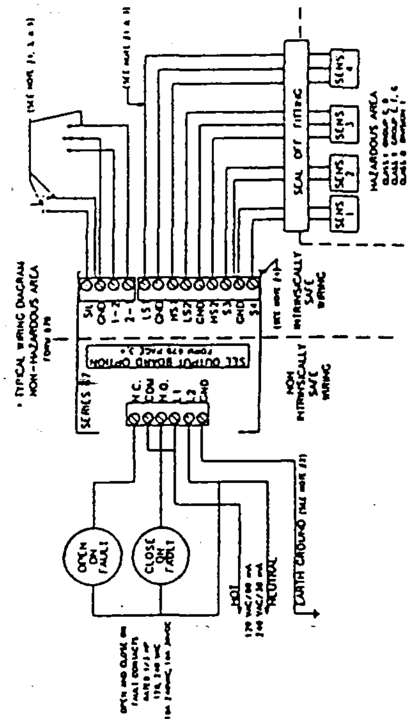
DIFFERENTIAL LEVEL SERVICE: DUPLEX PUMP UP WITHOUT ALTERNATION

Same operation as above disregarding the alternation sequence. Use the appropriate jumper to determine manual pump start sequence. Refer to FIG. 4 - 2 for the manual alternation jumper information.

General Control Information: Cont.







Notes:

1) All intrinsically safe wiring must be installed in accordance with article 504 of the National Electric Code, publication ANSI/NFPA 70. or CEC, Part 1 as Applicable

2) Grounding - The four mounting holes on the Series 67 provide an electrical connection for earth grounding between the controls internal solid state circuitry and the enclosure chassis. To insure proper grounding, use only metal screws and lock washers when mounting the control.

Terminal "G" on the supply line/load side terminal strip is a redundant system ground terminal and must be connected to the earth ground buss of the controls A.C. supply line feeder. The resistance between the system ground terminals and the earth ground buss must be less than 1 ohm.

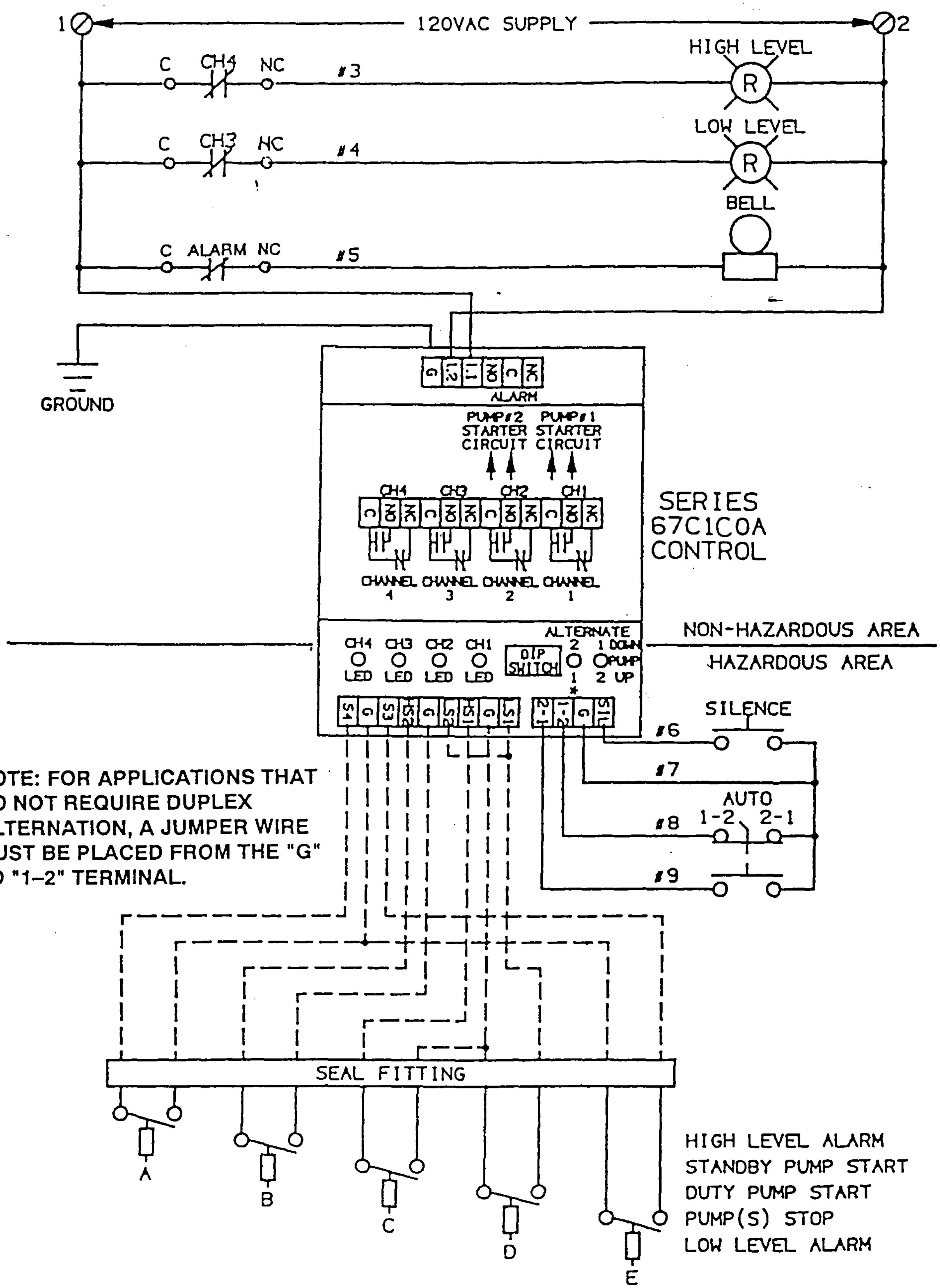
To prevent electrical shock from supply line/load side powered connections the Series 67 should be mounted in a metal enclosure of proper NEMA integrity.

3) The maximum total length of all of the intrinsically safe wiring (of each conductor) shall not exceed an accumulative value of 16,000 feet, excluding any ground wiring.

4) The intrinsically safe terminals of the series 67 can be connected to any non-energy generating or storing switch device such as a push button, a limit or float type switch or any of Warrick's electrode fitting assemblies.

5) When wiring alternation and bell silence switches, the switches and wiring must be separated from non-intrinsically safe circuits and wiring in accordance with article 504 of the National Electric Code, publication ANSI/NFPA 70. F or CEC, Part 1 as Applicabl

Sample Wiring Diagram:



* NOTE: FOR APPLICATIONS THAT DO NOT REQUIRE DUPLEX ALTERNATION, A JUMPER WIRE MUST BE PLACED FROM THE "G" TO "1-2" TERMINAL.

NOTES

WARRICK CONTROLS
WARRICK CONTROLS, INC.
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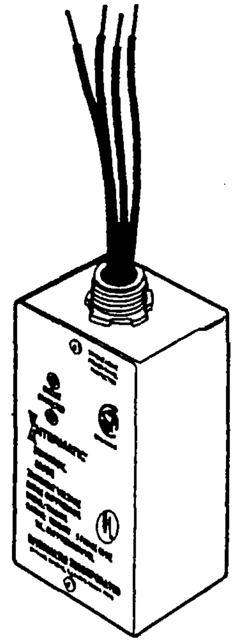
Telephone: (810) 549-4900
FAX: (810) 549-4904

When Control is Absolutely Essential

#670-A – 2M – 12/93 3RP

Printed in the U.S.A

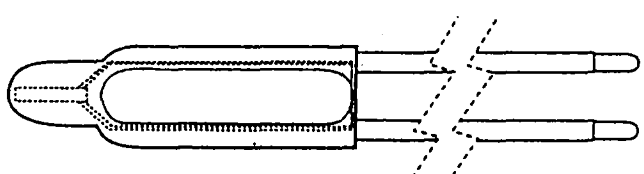
MODEL IG1240R
INSTRUCTION MANUAL



(FIG. 1)
CAUTION!

STEP 1

Electricity is dangerous if safety rules are not followed. Never work on equipment with the electricity turned "ON". Be absolutely certain the power is turned "OFF" at the circuit or device you are installing or repairing. If you are not able to determine that power is removed have it checked by a licensed electrician. Be sure you read carefully and understand all of the installation steps and have all the necessary tools and supplies before you begin to install the protector.
Check and follow your local electrical codes, they are for your protection.Do not touch electrical circuits or devices when you are wet or you are standing on a wet surface. Use a circuit tester or AC voltmeter to be sure the electricity is "OFF" before you touch wires or devices.
ELECTRICAL GROUND IS REQUIRED IN THIS UNIT.



(FIG. 2)
(NEON CIRCUIT TESTER)

STEP 2

Check all parts to be sure none are missing. You should have:

QUANTITY	DESCRIPTION
1	IG1240R Residential Panel ; Protector with a threaded connector and locking nut.
1	Conduit Nut

STEP 3

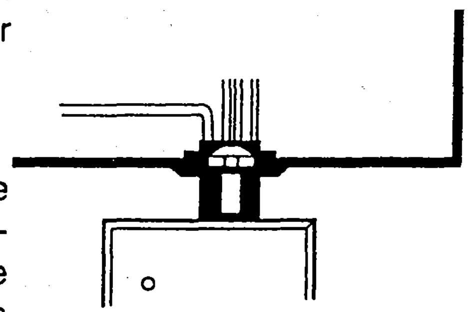
Select the mounting for the protector at the panel. If you have a panel that is not like the diagram (Fig. 3) call (815) 675-2321 for assistance between 8:00 am and 4:00 pm., weekdays, central time.

STEP 4

If you do not have a main power shut "OFF" (master switch) do not attempt the work. Call a licensed electrician. Turn the main breaker or shut off switch to the "OFF" position (or remove the main fuse pullout). Use caution, the incoming power cable may still be "hot" with electricity even with the rest of the panel turned "OFF". Use the circuit tester or AC voltmeter to be sure the circuits are off.

STEP 5

Carefully remove the front trim panel. Choose and remove the desired knockout through which the Protector wiring will enter into the breaker panel. Try to select a knockout that will allow you to use the shortest possible length of wire between the protector and the circuit breakers.



STEP 6

Install the Protector by inserting the wire and the threaded connector into the hole you knocked-out in the breaker panel and secure it with the locknut provided. If the breaker panel is recess mounted into the wall use the IG124FMP Flush Mounting Kit to recess the Protector. Follow the instructions packaged with the flush mounting kit.

STEP 7

Check to assure that the electricity is "OFF". A neon circuit tester or AC Voltmeter (Fig. 2) can be used, if you have one.

When connecting the wires, the green (ground) wire is connected first, then the white (neutral) wire and the black wires as shown in Figure 3. The black wires should be connected next to each other to two 15 or 20 ampere circuit breakers.

NOTE: The protector functions best if all bends in the wires are rounded, ideally to a 4" radius. Hard 90° bends reduce efficiency. Cut all leads to correct length. DO NOT COIL EXCESS LEAD.

STEP 8

Route the green wire to the ground bus bar provided in the breaker panel. Some panels do not have a separate ground bus bar so the green wire must then be connected to the neutral bus bar mentioned in Step 9. This wire must be connected for safety purposes.

STEP 9

Next, route and connect the white wire to the neutral bus bar provided in the breaker panel.

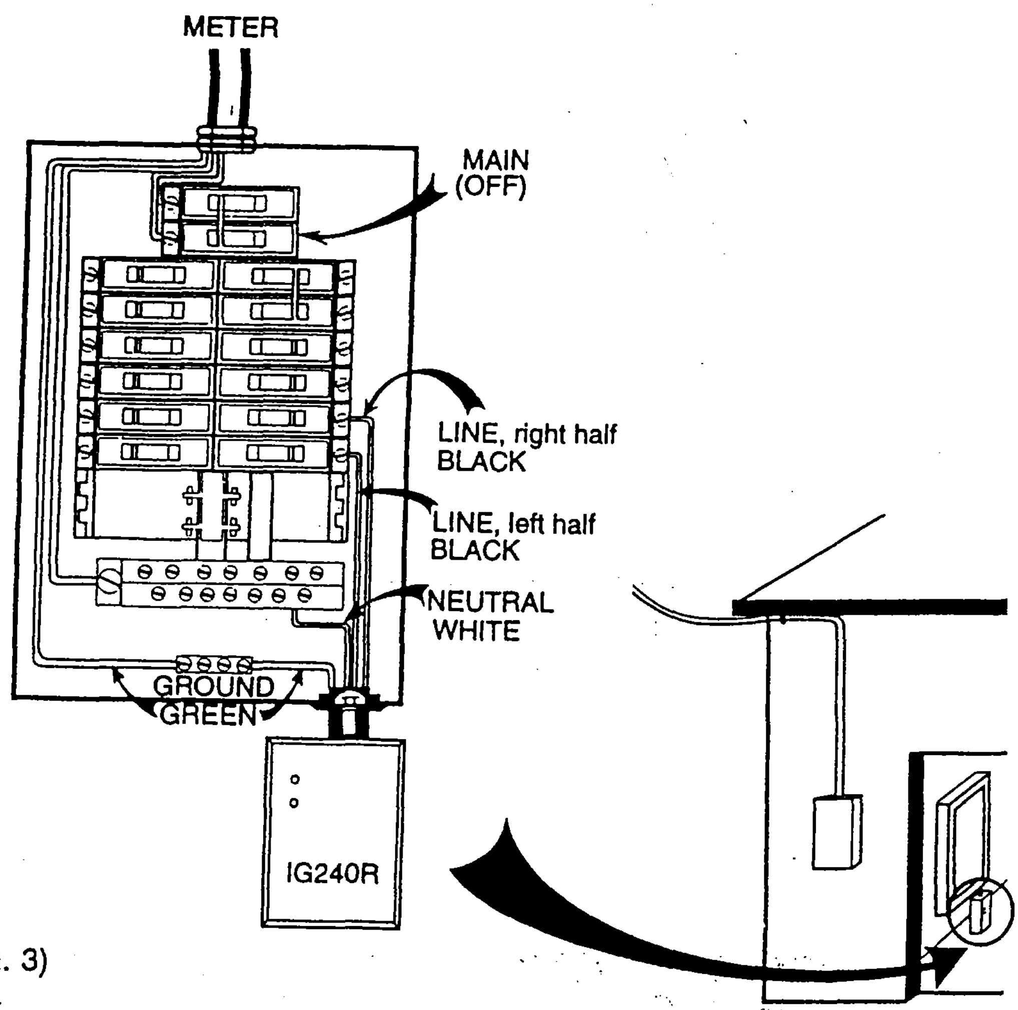
STEP 10

The two black wires remaining must be connected to two separate 15 or 20 amp circuit breakers, not to each other, to insure connection across the full 240 volt AC incoming power circuit, Use the AC voltmeter or circuit tester across the black wire connection to be sure the protector is providing full protection to your panel. No more than two wires should be connected to one circuit breaker. It may be necessary to add new breakers.

STEP 11

Check to be sure all wires are securely fastened and all screws are tight. You can confirm that the protector is wired to the correct breakers if you can read 220 to 240 volts AC between the two breakers that the protector is connected to. If there is no voltage between the two breakers, check to be sure that both of the breakers and the master breaker are 'ON'. If there is still no voltage between the two breakers, then they are probably on the same leg, and you will have to select another breaker for one of the black wires. BE SURE TO TURN OFF THE MAIN BREAKER BEFORE YOU ATTEMPT TO MOVE ANY WIRES.

Replace the front trim panel on the circuit breaker panel. *(continued on back...)*



(FIG. 3)

STEP 12

Turn "ON" the main breaker or shutoff switch (or insert the main fuse pullout).

STEP 13

Turn "ON the circuit breakers connected to the two black wires of the Protector. The two indicator lights on the Protector should be on and the panel protector is now functioning normally.

If the indicator lights are not on and the wiring has been determined to be correct, replace the unit.

Warranty and Limitation of Liability
Full five Year Warranty

If within five (5) years form the date of purchase, this Intermatic IG Series TVSS product fails due to a defect in material or workmanship, Intermatic Incorporated will repair or replace it free of charge. The warranty does not apply to: (a) damage caused by accident, abuse, mishandling, dripping; (b) units which have been subject to unauthorized repair, opened, taken apart; (c) units not used in accordance with directions; (d) damages exceeding the cost of the product. Some states do not allow a limitation of damages, so the foregoing limitations may not apply to you. This warranty gives you specific legal rights and you may also have other rights which vary from state to state. This warranty service is available by either (a) returning the product to the dealer from whom the unit was purchased, or (b) mailing postage prepaid to the service station listed. Please be sure to wrap the product securely when mailing to avoid shipping damage. This warranty is made by Intermatic Incorporated, Intermatic Plaza, Spring Grove, Illinois 60081-9698.

This unit is not a lightning arrestor and may not protect against a direct lightning strike on your home or at the electrical panel.

Authorized Service Station
Intermatic Incorporated
4720 West Montrose Avenue, Chicago, Illinois 60641

INTERMATIC INCORPORATED
SPRING GROVE, ILLINOIS 6001-9698

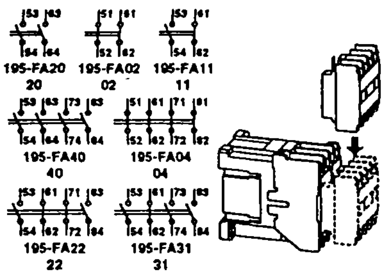
158EG8892 PRINTED IN U.S.A.

BULLETIN 100 -A09 -A12 -A18 -A24 -A30

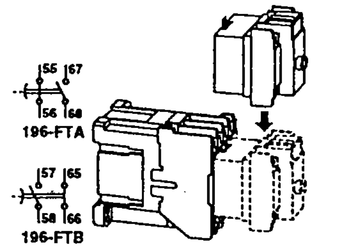
AC CONTACTOR
CONTACTEUR CA
AC SCHÜTZ
CONTACTOR CA
CONTATOR CA
CONTATTORE CA

ATTENTION: To prevent electrical shock, disconnect from power source before installing or servicing. Install in suitable enclosure. Keep free from contaminants. Do not lubricate or degrease magnet assemblies.
ATTENTION: Préalablement à l'installation et aux opérations de service, couper l'alimentation secteur pour empêcher touts chocs électriques. Installer dans une boite appropriée. Protéger le relais contre les contaminants. Ne jamais lubrifier ou dégraisser l'assemblage de l'aimant.
ACHTUNG: Vor Installations oder Servicearbeiten Stromversorgung zur Vermeidung von elektrischen Unfällen trennen. Die Gerate müssen in einem passenden Gehäuse eingebaut und gegen Verschmutzung geschützt werden. Der Magnetkern darf nicht geölt oder gefettet werden.
ATENCION: Desconéctese de la corriente eléctrica, antes de la instalación o del servicio, a fin de impedir sacudidas eléctricas. Instálelo en una caja apropiada. Manténgalo libre de contaminantes. No lubrique o desengrase los conjuntos magnéticos.
ATENÇÃO: Para evitar chouques, desconectar da corrente elétrica antes de fazer a instalaçao ou a manutençao. Instalar em caixa aproriada. Manter livre de contamlinantes. Náo lubrificar nem desengraxar os conjuntos magneticos.
ATTENZIONE: Togliere tensione prima dell'installazione. Installare in custodia idonea. Tenere lontano da contaminanti. Non lubrificare o sgrassare l'insieme del magnete.

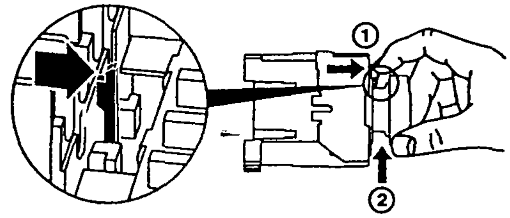
ADD-ON CONTACT BLOCK
BLOC DE CONTACTS
KONTAKTBLOCK-AUFSATZ
BLOQUE DE CONTACTOS SUPLEMENTARIO
BLOCO DE CONTATOS AUXILIARES
BLOCCHETTO ADDIZIONALE



PNEUMATIC TIMING UNIT
TEMPORISATEUR PNEUMATIQUE
PNEUMATISCHER ZEITRELAIS-AUFSATZ
UNIDAD TEMPORIZADORA NEUMATICA
UNIDADE DE TEMPO PNEUMÁTICA
TIMER PNEUMATICO

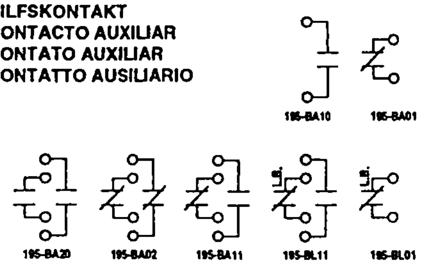


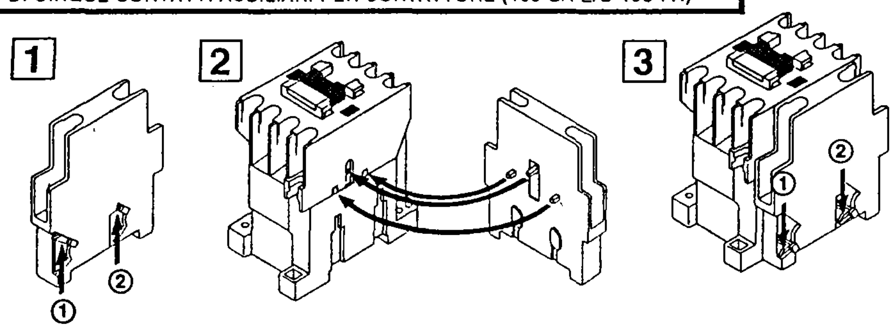
REMOVAL
DEMONTAGE
REMOVIBLE
REMOVÍVEL
RIMOZIONE



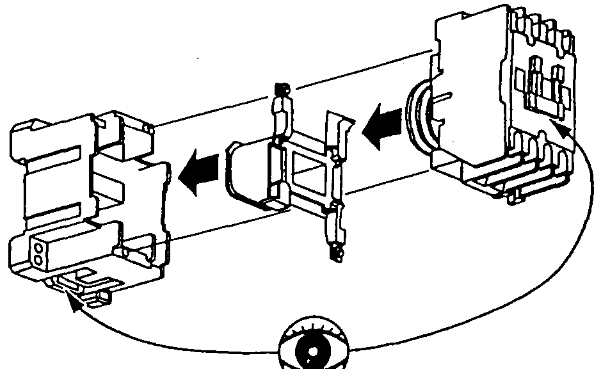
ATTENTION: DO NOT EXCEED FIVE AUXILIARY CIRCUITS PER CONTACTOR (195-BA AND/OR 195-FA)
ATTENTION: NE PAS UTILISER PLUS DE CINQ CIRCUITS AUXILIAIRES PAR CONTACTEUR (195-BA ET/OU 195-FA)
ACHTUNG: NICHT MEHR ALS FUNF HILFSKREISE JE SCHÜTZ (195-BA U/O 195-FA)
ATENCION: NO EXCEDER CINCO CIRCUITOS AUXILIARES POR CONTACTOR (195-BA Y/O 195-FA)
ATENÇÃO: NÃO EXCEDA CINCO CIRCUITOS AUXILIARES POR CONTATOR (195-BA E/OU 195-FA)
ATTENZIONE: NON UTILIZZARE PIU' DI CINQUE CONTATTI AUSILIARI PER CONTATTORE (195-BA E/O 195-FA)

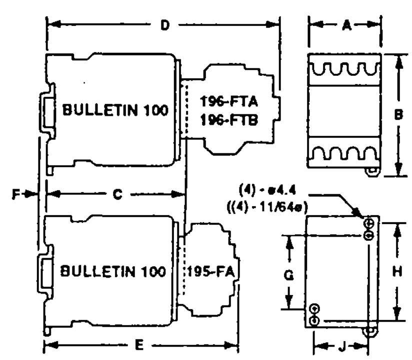
AUXILIARY CONTACT
CONTACT AUXILIAIRE
HILFSKONTAKT
CONTACTO AUXILIAR
CONTATO AUXILIAR
CONTATTO AUSILIARIO





COIL REPLACEMENT
REMPLACEMENT DE LA BOBINE
SPULE EINSETZUNG
CAMBIO DE BOBINA
SUBSTITUIÇÃO DA BOBINA
SOSTITUZIONE BOBINA





CAT		A WIDE	B HIGH	C	D	E	F	G	H	J
100-A09	mm	45	74	84	146	115	2	50	60	35
100-A12	in	1-49/64	2-29/32	3-5/16	5-47/64	4-17/32	5/64	1-31/32	2-23/64	1-3/8
100-A18	mm	55	83	92	152	123	2	60	75	35
100-A24	in	2-11/64	3-17/64	3-5/8	5-3/64	4-27/32	5/64	2-23/64	2-61/64	1-3/8
100-A30	mm	55	102	109	169	140	2	75	90	40
	in	2-11/64	4/1/64	4-19/64	6-21/32	5-33/64	5/64	2-61/64	3-35/64	1-37/64

40053-009-01(G)
Printed in U.S.A.

Rockwell Automation
Allen-Bradley

Using The Dialer

SELECTING THE NUMBER OF DIAL ATTEMPTS

You can set the dialer to call each stored number one time only, or you can set it to call each number up to three times until each call has been answered or dialed three times.

To switch between these two settings, press TEST, then 0.

The dialer sounds a tone when you have set it to call three times. The dialer sounds no tone when you set it on three times. The dialer sounds no tone when you set it to call one time only.

ALARM CONDITIONS

When your alarm is triggered, it signals the dialer to begin dialing. The dialer follows this sequence.

1. It goes off-hook, then pauses 15 seconds to

   disconnect any answering machine that might be operating on the line.

2. It dials the first number and waits 5 to 6 rings for the called party to answer.

3. If someone answers, the dialer sounds five single tones for a fire alarm or five high-low sounds for a burglar alarm and then plays your outgoing message.

   Note: A fire alarm takes precedence over a burglar alarm.

4. If someone answered at the first number and the outgoing message was played, the dialer repeats Steps 2 and 3 for each of the stored numbers.

5. If no one answers, it begins at Step 2 for

   the next stored numbers.

NOTES:

- If you set the dialer to dial only one time, it stops after dialing the third number- even if no one answered.
- If you set the dialer to dial three times, the dialer repeats Steps 2 and 3 for all unanswered numbers until either someone answers or the numbers have been dialed three times
- If the dialer detects busy tones, it tries to recall that number if you programmed the dialer to call each number three times.

Recording An Outgoing Message

When the alarm system is violated, the dialer plays the outgoing message you recorded. Follow these steps to record the outgoing message.

Note: The message can be up to 20 seconds long.

1. Press RECORD. The RECORD indicator lights
2. From 12 inches away, clearly speak your message into the microphone on the front of the dialer.
3. If your message is less then 20 seconds long, press **RECORD** when you finish your recording.

   The **RECORD** indicator turns off after the 20 seconds elapse.

Here is a typical outgoing message:

"This is John Doe Residence at 812 Maple Street. If you heard five single tones at the start of this message, our alarm is indicating a fire. Notify the fire department. If you heard five high-low tones at the start of this message, our alarm is indicating a burglary. Notify the police department."

STORING TELEPHONE NUMBERS IN MEMORY

You can enter up to three numbers to be dialed in the event of an alarm. Follow these steps to enter a number.

You should program the dialer to call a friend who can determine if ther is a real problem. The person can then call the police. If necessary, or call you back to see if everything is fine. You should NOT program the dialer to dial the police directly, unless your local police has a special line for emergency dialers.

1. Press **STORE.**
2. Press 1,2, or 3 to select the memory location for the number.
3. Enter the telephone number (up to 16 digits).
4. Press **STORE.** The dialer sounds a one second beep.

If you make a mistake while entering a number, begin again from Step 1.

Notes:

- If you try to save more than 16 digits the dialer does not store the number.
- If you use the dialer on a telephone system that requires you to dial an access code for an outside line, you must program a pause after the access code to allow time for the outside line to connect. The program a 2-second pause between digits, press **PLAY/PAUSE** at the point in the dialing sequence where you need to pause.
- Each pause entry causes the dialer to pause for about 2 seconds. Pressing **PLAY/PAUSE** counts as one of the 16 digits availbe in a memory location.

CLEARING A TELEPHONE NUMBER FROM MEMORY

To delete a number from memory, enter another phone number in the same memory location or follow these steps:

1. Press **STORE.**

2. Press the memory location (1,2, or 3) you want to clear.

3. Press **STORE.** The dialer sounds a one-second beep.

Testing The Dialer

You can test the outgoing message and entered phone numbers by pressing **TEST** followed by the number to be tested (1, 2, or 3). The dialer dials the number and plays the outgoing message if the called party answers. If it is not answered, the dialer exists the test mode and sounds three short beeps.

When programming emergency numbers or making test calls to emergency numbers, remain on the line and breifly explain the reason for the call before hanging up. Perform such activites in the off-peak hours, such as early morning hours or late evenings.

Notes:

- Before you use the test mode, explain to the called party the reason for the call.
- If the memory location to be tested, has not been programmed or has been deleted, the dialer sounds three short beeps.
- If the called party hangs up, the dialer does not detect this, and it continues with the outgoing message.

MONITORING THE OUTGOING MESSAGE

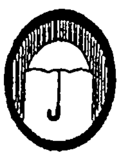
You can monitor the outgoing audio messasge and verify operation by setting MONITOR to the **IN** postion. You can mute the outgoing message by setting **MONITOR** to the **out** position.

PLAYING YOUR OUTGOING MESSAGE

You can test the outgoing message by setting MONITOR to the **IN** postion and pressing PLAY/PAUSE. To stop playback before it is completed, press **PLAY/PAUSE** again. Otherwise the dialer automatically stops playing back when it reaches the end of the message.

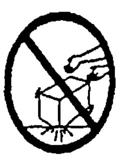
CARE AND MAINTENANCE

Your NEPCCO TEL-10 is an example of superior design and craftsmanship. The following suggestions will help care for the dialer so you can enjoy it for years.



Keep the dialer dry. If it gets wet, wipe it dry immediately. Liquids might contain minerals that can corrode electronic circuits.

Use and store the dialer only in normal temperature environments. Temperature extremes can shorten the life of electronic devices and distort or merit plastic parts.



Handle the dialer gently and carefully. Dropping it can damage circuit boards and cases and can cause the dialer to work improperly.

Keep the dialer away from dust and dirt , which can cause premature wear of parts.

Wipe the dialer with a damp cloth occasionally to keep the dialer looking new. Do not use harsh chemicals, cleaning solvents, or strong detergents to clean the dialer.

PRINTER CONFIGURATION:

Pr[illegible]r Device Name..: HPLJ4_C
P[illegible] Device Desc..: HJ LaserJet 4 - for compressed ladder report only.
C[illegible]d Graphics.....: Yes
Allows Enhanced Mode.: Yes
Paper Type (w/h).....: Custom 8 x 10
Normal Chars/Inch....: 10
Compressed Chars/Inch: 20
Lines per Inch.......: 9
Print Initialize.....: 27 69 27 38 108 48 79 27 38 107 48 83 27 38 108 53 67 27 40 49 48 85
Compressed Print.....: 27 38 107 50 83 27 38 107 54 72
Normal Print.........: 27 38 107 48 83 27 38 107 49 50 72
Expanded Print.......: 27 38 107 48 83 27 38 107 49 50 72

REPORT CONFIGURATION:

Report Configuration File: C:\SLC500\PROGS\MORSE01\DEFAULT.RCF
Ladder Report............: Yes
Xref Report..............: Yes
Data Table Dump Report...: Yes
Data Table Usage Report..: Yes
Data Base Form...........: Address
Unused Address Report....: Yes
Program File List Report.: Yes
Data File List Report....: Yes
Sequencer Data Report....: No
Processor Config Report..: No
Rack Description Report..: Oview+Full
I/O Parts List Report....: Yes
Revision History.........: Yes
Table of Contents........: Yes

LADDER REPORT CONFIGURATION:

Rung Print List..........: ALL
Ladder Print Mode........: Compressed
Rung Desc. Print Mode....: Fit in Rung
Box Rung Description.....: No
Chk Page on Vert Split...: No
# of Des Lines to print..: 5
Symbolic Mode............: Normal
Show I/O Cards...........: Yes
Output Xref..............: Side/Below
I[illegible]Xref...............: Yes
L[illegible]Xref Print Mode...: Normal
Ig[illegible] Xref Disable Flg..: No
Force Addr on Side xref..: No
Side Xref Column Width...: 32
Print Right Power Rail...: Yes
Print MSG/PID Config.....: No

CROSS REFERENCE REPORT CONFIGURATION:

Xref Sort Mode...........: Address
Xref Mode................: Compressed
Print Descriptions.......: Yes
Print Symbols............: Yes
Replace Addr w/Sym.......: No
Xref Printer Mode........: Normal
Group bits into word.....: No
Margin between xrefs.....: 0

PRINTER CONFIGURATION:

Printer Device Name..: HPLJ4_C
Printer Device Desc..: HJ LaserJet 4 - for compressed ladder report only.
Use IBM Graphics.....: Yes
Allows Enhanced Mode.: Yes
Paper Type (w/h).....: Custom 8 x 10
Normal Chars/Inch....: 10
Compressed Chars/Inch: 20
Lines per Inch.......: 9
Print Initialize.....: 27 69 27 38 108 48 79 27 38 107 48 83 27 38 108 53 67 27 40 49 48 85
Compressed Print.....: 27 38 107 50 83 27 38 107 54 72
Normal Print.........: 27 38 107 48 83 27 38 107 49 50 72
Expanded Print.......: 27 38 107 48 83 27 38 107 49 50 72

REPORT CONFIGURATION:

Report Configuration File: C:\SLC500\PROGS\MORSE01\DEFAULT.RCF
Ladder Report............: Yes
Xref Report..............: Yes
Data Table Dump Report...: Yes
Data Table Usage Report..: Yes
Data Base Form...........: Address
Unused Address Report....: Yes
Program File List Report.: Yes
Data File List Report....: Yes
Sequencer Data Report....: No
Processor Config Report..: No
Rack Description Report..: Oview+Full
I/O Parts List Report....: Yes
Revision History.........: Yes
Table of Contents........: Yes

LADDER REPORT CONFIGURATION:

Rung Print List..........: ALL
Ladder Print Mode........: Compressed
Rung Desc. Print Mode....: Fit in Rung
Box Rung Description.....: No
Chk Page on Vert Split...: No
# of Des Lines to print..: 5
Symbolic Mode............: Normal
Show I/O Cards...........: Yes
Output Xref..............: Side/Below
Input Xref...............: Yes
Ladder Xref Print Mode...: Normal
Ignore Xref Disable Flg..: No
Force Addr on Side xref..: No
Side Xref Column Width...: 32
Print Right Power Rail...: Yes
Print MSG/PID Config.....: No

CROSS REFERENCE REPORT CONFIGURATION:

Xref Sort Mode...........: Address
Xref Mode................: Compressed
Print Descriptions.......: Yes
Print Symbols............: Yes
Replace Addr w/Sym.......: No
Xref Printer Mode........: Normal
Group bits into word.....: No
Margin between xrefs.....: 0

```
   SYSTEM                                                    LSHH-1 ALARM
   (RESET)/RUN                                               BIT
   RESET)RUN                                                 LSHH-1_ALARM
   I:0.0                                                     B3              -(L)- - File #2 - 3
0 ---|/|-------------------------------------------------+---(U)---+       -(U)- - File #2 - 0
     0                                                   |   0     |       -| |- - File #2 - 4
   I40A                                                  |         |       -|/|- - File #2 - 5, 7, 9, 11
                                                         | LSHH-2 ALARM
                                                         | BIT
                                                         | LSHH-2_ALARM
                                                         | B3                B3/1 - -(L)- - File #2 - 5
                                                         +---(U)---+              -(U)- - File #2 - 0
                                                         |   1     |              -| |- - File #2 - 6
                                                         |         |              -|/|- - File #2 - 3, 7
                                                         |         |                     9, 11
                                                         | LSHH-3/LSHH-6
                                                         | ALARM BIT
                                                         | LSHH-3\6_ALARM
                                                         | B3                B3/2 - -(L)- - File #2 - 7
                                                         +---(U)---+              -(U)- - File #2 - 0
                                                         |   2     |              -| |- - File #2 - 8
                                                         |         |              -|/|- - File #2 - 3, 5
                                                         |         |                     9, 11
                                                         | LSHH-4 ALARM
                                                         | BIT
                                                         | LSHH-4_ALARM
                                                         | B3                B3/3 - -(L)- - File #2 - 9
                                                         +---(U)---+              -(U)- - File #2 - 0
                                                         |   3     |              -| |- - File #2 - 10
                                                         |         |              -|/|- - File #2 - 3, 5
                                                         |         |                     7, 11
                                                         | LSHH-5 ALARM
                                                         | BIT
                                                         | LSHH-5_ALARM
                                                         | B3                B3/4 - -(L)- - File #2 - 11
                                                         +---(U)---+              -(U)- - File #2 - 0
                                                         |   4     |              -| |- - File #2 - 12
                                                         |         |              -|/|- - File #2 - 3, 5
                                                         |         |                     7, 9
                                                         | GLOBAL ALARM
                                                         | BIT
                                                         | GLOBAL_ALARM
                                                         | B3                B3/5 - -(L)- - File #2 - 3, 5
                                                         +---(U)---+                     7, 9, 11
                                                             5                    -(U)- - File #2 - 0 ...
 B3/5 - -| |- - File #2 - 13
        -|/|- - File #2 - 16, 19, 22, 25, 28, 31, 33, 34, 36, 37
   EM                                                        SYSTEM RUN
   OFF(RESET)/RUN                                            LAMP
   OFF(RESET)RUN                                             SYS_RUN_LAMP
   I:0.0                                                     O:0.0
1 ---| |-----------------------------------------------------( )---
     0                                                       10
   I40A                                                      I40A
   SYSTEM                                                    SYSTEM OFF
   OFF(RESET)/RUN                                            LAMP
   OFF(RESET)RUN                                             SYS_OFF_LAMP
   I:0.0                                                     O:1.0
2 ---|/|-----------------------------------------------------( )---
     0                                                       2
   I40A                                                      OX8
   SEPARATOR
   TANK T-1 LEVEL  LSHH-2 ALARM  LSHH-3/LSHH-6  LSHH-4 ALARM  LSHH-5 ALARM     LSHH-1 ALARM
   SWITCH HI-HI #1 BIT           ALARM BIT      BIT           BIT              BIT
   LSHH-1          LSHH-2_ALARM  LSHH-3\6_ALARM LSHH-4_ALARM  LSHH-5_ALARM     LSHH-1_ALARM
   I:0.0           B3            B3             B3            B3               B3          -(L)- - File #2 - 3
3 ---| |-----------|/|-----------|/|------------|/|-----------|/|----------+---(L)---+     -(U)- - File #2 - 0
     12            1             2              3             4            |   0     |     -| |- - File #2 - 4
   I40A           [5]           [0]            [0]           [0]           |         |     -|/|- - File #2 - 5, 7, 9, 11
                                                                           | GLOBAL ALARM
                                                                           | BIT
                                                                           | GLOBAL_ALARM
                                                                           | B3              B3/5 - -(L)- - File #2 - 3, 5
                                                                           +---(L)---+                     7, 9, 11
                                                                               5                    -(U)- - File #2 - 0 ...
 B3/5 - -| |- - File #2 - 13
        -|/|- - File #2 - 16, 19, 22, 25, 28, 31, 33, 34, 36, 37
   LSHH-1 ALARM  FLASHER BIT                                 LSHH-1 ALARM
   BIT           1.28 SEC                                    LAMP
   LSHH-1_ALARM  FLASHER                                     LSHH-1_ALM_LAMP
   B3            S:4                                         O:0.0
4 ---| |-----------| |---------------------------------------( )---
     0             7                                         12
  [3]                                                        I40A
```

```
 |SYSTEM                                                   LSHH-1 ALARM
 |OFF(RESET)/RUN                                           BIT
 |OFF(RESET)RUN                                            LSHH-1_ALARM
 |  I:0.0                                                      B3          -(L)- - File #2 - 3
0|---]/[------------------------------------------------------(U)---------  -(U)- - File #2 - 0
 |    0                                                        0           -] [- - File #2 - 4
 |   L40A                                                                  -]/[- - File #2 - 5, 7, 9, 11
 |                                                         LSHH-2 ALARM
 |                                                         BIT
 |                                                         LSHH-2_ALARM
 |                                                             B3          B3/1 - -(L)- - File #2 - 5
 |                                                         ---(U)---              -(U)- - File #2 - 0
 |                                                             1                  -] [- - File #2 - 6
 |                                                                                -]/[- - File #2 - 3, 7
 |                                                         LSHH-3/LSHH-6                  9, 11
 |                                                         ALARM BIT
 |                                                         LSHH-3\6_ALARM
 |                                                             B3          B3/2 - -(L)- - File #2 - 7
 |                                                         ---(U)---              -(U)- - File #2 - 0
 |                                                             2                  -] [- - File #2 - 8
 |                                                                                -]/[- - File #2 - 3, 5
 |                                                         LSHH-4 ALARM                   9, 11
 |                                                         BIT
 |                                                         LSHH-4_ALARM
 |                                                             B3          B3/3 - -(L)- - File #2 - 9
 |                                                         ---(U)---              -(U)- - File #2 - 0
 |                                                             3                  -] [- - File #2 - 10
 |                                                                                -]/[- - File #2 - 3, 5
 |                                                         LSHH-5 ALARM                   7, 11
 |                                                         BIT
 |                                                         LSHH-5_ALARM
 |                                                             B3          B3/4 - -(L)- - File #2 - 11
 |                                                         ---(U)---              -(U)- - File #2 - 0
 |                                                             4                  -] [- - File #2 - 12
 |                                                                                -]/[- - File #2 - 3, 5
 |                                                         GLOBAL ALARM                   7, 9
 |                                                         BIT
 |                                                         GLOBAL_ALARM
 |                                                             B3          B3/5 - -(L)- - File #2 - 3, 5
 |                                                         ---(U)---                      7, 9, 11
 |                                                             5                  -(U)- - File #2 - 0 ...
 |B3/5 - -] [- - File #2 - 13
 |        -]/[- - File #2 - 16, 19, 22, 25, 28, 31, 33, 34, 36, 37
 |SYSTEM                                                   SYSTEM RUN
 |OFF(RESET)/RUN                                           LAMP
 |OFF(RESET)RUN                                            SYS_RUN_LAMP
 |  I:0.0                                                     O:0.0
1|---] [------------------------------------------------------( )---------
 |    0                                                        10
 |   L40A                                                     L40A
 |SYSTEM                                                   SYSTEM OFF
 |OFF(RESET)/RUN                                           LAMP
 |OFF(RESET)RUN                                            SYS_OFF_LAMP
 |  I:0.0                                                     O:1.0
2|---]/[------------------------------------------------------( )---------
 |    0                                                         2
 |   L40A                                                      OX8
 |SEPARATOR
 |TANK T-1 LEVEL  LSHH-2 ALARM  LSHH-3/LSHH-6  LSHH-4 ALARM  LSHH-5 ALARM     LSHH-1 ALARM
 |SWITCH HI-HI #1 BIT           ALARM BIT      BIT           BIT              BIT
 |LSHH-1          LSHH-2_ALARM  LSHH-3\6_ALARM LSHH-4_ALARM  LSHH-5_ALARM     LSHH-1_ALARM
 |  I:0.0             B3            B3             B3            B3               B3        -(L)- - File #2 - 3
3|---] [-----------]/[----------]/[----------]/[----------]/[--------------------(L)-------  -(U)- - File #2 - 0
 |    12               1             2              3             4                0        -] [- - File #2 - 4
 |   L40A          [5]           [0]            [0]           [0]                           -]/[- - File #2 - 5, 7, 9, 11
 |                                                                            GLOBAL ALARM
 |                                                                            BIT
 |                                                                            GLOBAL_ALARM
 |                                                                                B3        B3/5 - -(L)- - File #2 - 3, 5
 |                                                                            ---(L)---                    7, 9, 11
 |                                                                                5              -(U)- - File #2 - 0 ...
 |B3/5 - -] [- - File #2 - 13
 |        -]/[- - File #2 - 16, 19, 22, 25, 28, 31, 33, 34, 36, 37
 |LSHH-1 ALARM  FLASHER BIT                                   LSHH-1 ALARM
 |BIT           1.28 SEC                                      LAMP
 |LSHH-1_ALARM  FLASHER                                       LSHH-1_ALM_LAMP
 |    B3           S:4                                           O:0.0
4|---] [---------] [-------------------------------------------( )---------
 |    0             7                                             12
 |[3]                                                            L40A
```

```
   |5000 GALLON
    ORAGE TANK
    5 LEVEL       LSHH-1 ALARM  LSHH-2 ALARM  LSHH-3/LSHH-6  LSHH-4 ALARM                       LSHH-5 ALARM
   ITCH HI-HI #5  BIT           BIT           ALARM BIT      BIT                                BIT
   |LSHH-5        LSHH-1_ALARM  LSHH-2_ALARM  LSHH-3\6_ALARM LSHH-4_ALARM                       LSHH-5_ALARM
      I:0.1          B3            B3            B3             B3                                 B3          -(L)- - File #2 - 11
11 |---] [-----------]/[-----------]/[-----------]/[------------]/[-------------------------------+---(L)---+-  -(U)- - File #2 - 0
       2             0             1             2              3                               |    4    |   -] [- - File #2 - 12
     I40A          [3]           [5]           [7]            [9]                               |         |   -]/[- - File #2 - 3, 5, 7, 9
                                                                                                |GLOBAL ALARM
                                                                                                |BIT      |
                                                                                                |GLOBAL_ALARM
                                                                                                |    B3   |   B3/5 - -(L)- - File #2 - 3, 5
                                                                                                +---(L)---+                7, 9, 11
                                                                                                     5              -(U)- - File #2 - 0 ...

   B3/5 - -] [- - File #2 - 13
          -]/[- - File #2 - 16, 19, 22, 25, 28, 31, 33, 34, 36, 37
   LSHH-5 ALARM  FLASHER BIT                                                                    LSHH-5 ALARM
   BIT           1.28 SEC                                                                       LAMP
   LSHH-5_ALARM  FLASHER                                                                        LSHH-5_ALM_LAMP
       B3          S:4                                                                             O:1.0
12 |---] [---------] [------------------------------------------------------------------------------( )--------|
       4           7                                                                                  0
   [11]                                                                                              CX8
   GLOBAL ALARM
   BIT                                                                                          WARNING BEACON
   GLOBAL_ALARM                                                                                 WARNING_BEACON
       B3                                                                                          O:1.0
13 |---] [-----------------------------------------------------------------------------------+------( )------+-|
       5                                                                                     |        1      |
   [11]                                                                                      |       CX8     |
                                                                                             |ALARM OUTPUT   |
                                                                                             |TO AUTODIALER  |
                                                                                             |ALM_OUT_DIALER |
                                                                                             |     O:1.0     |
                                                                                             +------( )------+
                                                                                                      7
                                                                                                     CX8

   SYSTEM            MV-1 MINUTE                                                            MV-1 MINUTE
   OFF(RESET)/RUN    TIMER                                                                  TIMER
   OFF(RESET)RUN     MV-1_TIMER                                                             MV-1_TIMER
      I:0.0            T4:1                                                                 +-TON-----------+
   ----] [------------]/[-------------------------------------------------------------------|Timer On Delay |-(EN)-  TON - File #2 - 14
        0              DN                                                                   |Timer     T4:1 |-(DN)   RES - File #2 - 29
      I40A            [14]                                                                  |Time Base 0.01 |        T4:1.DN - -] [- - File #2 - 15
                                                                                            |Preset    6000 |                  -]/[- - File #2 - 14
                                                                                            |Accum        0 |
                                                                                            +---------------+

   MV-1 MINUTE                                                                              MV-1 MINUTE
   TIMER                                                                                    COUNTER
   MV-1_TIMER                                                                               MV-1_MIN_COUNT
     T4:1                                                                                   +-CTU-----------+
15 |---] [----------------------------------------------------------------------------------|Count Up       |-(CU)-  CTU - File #2 - 15
       DN                                                                                   |Counter   C5:1 |-(DN)   RES - File #2 - 29
   [14]                                                                                     |Preset      30 |        C5:1.DN - -] [- - File #2 - 17
                                                                                            |Accum        0 |                               19
                                                                                            +---------------+                  -]/[- - File #2 - 16

   MOTORIZED
   VALVE MV-1   MV-1 MINUTE     GLOBAL ALARM                                                        MOTORIZED
   AUTO         COUNTER         BIT                                                                 VALVE MV-1
   MV-1_AUTO    MV-1_MIN_COUNT  GLOBAL_ALARM                                                        MV-1
     I:0.0         C5:1            B3                                                                  O:0.0       -( )- - File #2 - 16
16 |---] [-----------]/[-------------]/[-----------------------------------------------------------------( )--------  -] [- - File #2 - 31
       1           DN              5                                                                     0
     I40A        [15]            [11]                                                                  I40A
   MV-1 MINUTE     MV-2 MINUTE                                                              MV-2 MINUTE
   COUNTER         TIMER                                                                    TIMER
   MV-1_MIN_COUNT  MV-2_TIMER                                                               MV-2_TIMER
     C5:1            T4:2                                                                   +-TON-----------+
17 |---] [------------]/[-------------------------------------------------------------------|Timer On Delay |-(EN)-  T4:2.DN - -] [- - File #2 - 18
       DN             DN                                                                    |Timer     T4:2 |-(DN)             -]/[- - File #2 - 17
   [15]            [17]                                                                     |Time Base 0.01 |
                                                                                            |Preset    6000 |
                                                                                            |Accum        0 |
                                                                                            +---------------+

   MV-2 MINUTE                                                                              MV-2 MINUTE
   TIMER                                                                                    COUNTER
   MV-2_TIMER                                                                               MV-2_MIN_COUNT
     T4:2                                                                                   +-CTU-----------+
18 |---] [----------------------------------------------------------------------------------|Count Up       |-(CU)-  CTU - File #2 - 18
       DN                                                                                   |Counter   C5:2 |-(DN)   RES - File #2 - 29
   [17]                                                                                     |Preset      60 |        C5:2.DN - -] [- - File #2 - 20
                                                                                            |Accum        0 |                               22
                                                                                            +---------------+                  -]/[- - File #2 - 19
```

```
   |5000 GALLON
   |STORAGE TANK
   |T-6 LEVEL        LSHH-1 ALARM  LSHH-2 ALARM  LSHH-3/LSHH-6  LSHH-4 ALARM                  LSHH-5 ALARM
   |SWITCH HI-HI #5  BIT           BIT           ALARM BIT      BIT                           BIT
   |LSHH-5           LSHH-1_ALARM  LSHH-2_ALARM  LSHH-3\6_ALARM LSHH-4_ALARM                  LSHH-5_ALARM
   |   I:0.1             B3            B3            B3             B3                           B3          -(L)- - File #2 - 11
11 |----] [-----------]/[----------]/[-----------]/[------------]/[-------------------------+--(L)--+        -(U)- - File #2 - 0
   |    2                0             1             2              3                        |   4   |        ] [ - File #2 - 12
   |   L40A         [3]           [5]           [7]           [9]                            |       |        ]/[ - File #2 - 3, 5, 7, 9
   |                                                                                         |GLOBAL ALARM
   |                                                                                         |BIT
   |                                                                                         |GLOBAL_ALARM
   |                                                                                         |   B3  |       B3/5 - -(L)- - File #2 - 3, 5
   |                                                                                         +--(L)--+              7, 9, 11
   |                                                                                             5                -(U)- - File #2 - 0 ...

   |B3/5 - ] [ - File #2 - 13
   |       ]/[ - File #2 - 16, 19, 22, 25, 28, 31, 33, 34, 36, 37
   |LSHH-5 ALARM  FLASHER BIT                                                           LSHH-5 ALARM
   |BIT           1.28 SEC                                                              LAMP
   |LSHH-5_ALARM  FLASHER                                                               LSHH-5_ALM_LAMP
   |    B3           S:4                                                                    O:1.0
12 |----] [---------] [-----------------------------------------------------------------------( )----
   |    4            7                                                                        0
   |[11]                                                                                     OX8
   |GLOBAL ALARM
   |BIT                                                                                WARNING BEACON
   |GLOBAL_ALARM                                                                       WARNING_BEACON
   |    B3                                                                                  O:1.0
13 |----] [---------------------------------------------------------------------------+-----( )----
   |    5                                                                              |      1
   |[11]                                                                               |     OX8
   |                                                                                   |ALARM OUTPUT
   |                                                                                   |TO AUTODIALER
   |                                                                                   |ALM_OUT_DIALER
   |                                                                                   |    O:1.0
   |                                                                                   +-----( )
   |                                                                                          7
   |                                                                                         OX8

   |SYSTEM           MV-1 MINUTE                                              MV-1 MINUTE
   |OFF(RESET)/RUN   TIMER                                                    TIMER
   |OFF(RESET)RUN    MV-1_TIMER                                               MV-1_TIMER
   |   I:0.0            T4:1                                                  +-TON--------------+       TON - File #2 - 14
14 |----] [------------]/[----------------------------------------------------+Timer On Delay    +-(EN)-  RES - File #2 - 29
   |    0               DN                                                    |Timer        T4:1 +-(DN)   T4:1.DN - ] [ - File #2 -
   |   L40A         [14]                                                      |Time Base    0.01 |                 ]/[ - File #2 -
   |                                                                          |Preset       6000 |
   |                                                                          |Accum           0 |
   |                                                                          +------------------+
   |MV-1 MINUTE                                                               MV-1 MINUTE
   |TIMER                                                                     COUNTER
   |MV-1_TIMER                                                                MV-1_MIN_COUNT
   |   T4:1                                                                   +-CTU--------------+       CTU - File #2 - 15
15 |----] [-------------------------------------------------------------------+Count Up          +-(CU)-  RES - File #2 - 29
   |    DN                                                                    |Counter      C5:1 +-(DN)   C5:1.DN - ] [ - File #2 - 17
   |[14]                                                                      |Preset         30 |                              19
   |                                                                          |Accum           0 |                 ]/[ - File #2 - 16
   |                                                                          +------------------+
   |MOTORIZED
   |VALVE MV-1  MV-1 MINUTE     GLOBAL ALARM                                        MOTORIZED
   |AUTO        COUNTER         BIT                                                 VALVE MV-1
   |MV-1_AUTO   MV-1_MIN_COUNT  GLOBAL_ALARM                                        MV-1
   |   I:0.0        C5:1            B3                                                 O:0.0            -( )- - File #2 - 16
16 |----] [---------]/[-------------]/[------------------------------------------------( )----        ] [ - File #2 - 31
   |    1           DN              5                                                  0
   |   L40A    [15]            [11]                                                   L40A
   |MV-1 MINUTE     MV-2 MINUTE                                               MV-2 MINUTE
   |COUNTER         TIMER                                                     TIMER
   |MV-1_MIN_COUNT  MV-2_TIMER                                                MV-2_TIMER
   |    C5:1           T4:2                                                   +-TON--------------+       T4:2.DN - ] [ - File #2 - 18
17 |----] [-----------]/[-----------------------------------------------------+Timer On Delay    +-(EN)-           ]/[ - File #2 - 17
   |    DN             DN                                                     |Timer        T4:2 +-(DN)
   |[15]           [17]                                                       |Time Base    0.01 |
   |                                                                          |Preset       6000 |
   |                                                                          |Accum           0 |
   |                                                                          +------------------+
   |MV-2 MINUTE                                                               MV-2 MINUTE
   |TIMER                                                                     COUNTER
   |MV-2_TIMER                                                                MV-2_MIN_COUNT
   |   T4:2                                                                   +-CTU--------------+       CTU - File #2 - 18
18 |----] [-------------------------------------------------------------------+Count Up          +-(CU)-  RES - File #2 - 29
   |    DN                                                                    |Counter      C5:2 +-(DN)   C5:2.DN - ] [ - File #2 - 20
   |[17]                                                                      |Preset         60 |                              22
   |                                                                          |Accum           0 |                 ]/[ - File #2 - 19
   |                                                                          +------------------+
```

```
 |MOTORIZED
  ~LVE MV-5  MV-5 MINUTE    MV-4 MINUTE    GLOBAL ALARM                                MOTORIZED
  O          COUNTER        COUNTER        BIT                                         VALVE MV-5
  -5_AUTO    MV-5_MIN_COUNT MV-4_MIN_COUNT GLOBAL_ALARM                                MV-5
  I:0.0         C5:5           C5:4           B3                                       O:0.0        |-( )- - File #2 - 28
28|---] [-----------]/[----------] [----------]/[--------------------------------------( )------|-] [- - File #2 - 31
    5           DN             DN             5                                         4
  L40A    [27]          [29]           [11]                                            L40A
  MV-5 MINUTE                                                              MV-1 MINUTE
  COUNTER                                                                  COUNTER
  MV-5_MIN_COUNT                                                           MV-1_MIN_COUNT
     C5:5                                                                     C5:1      |CTU - File #2 - 15
29|--+--] [--+-------------------------------------------------------------+--[RES]-----|RES - File #2 - 29
     |   DN  |                                                             |            |C5:1.DN - -] [- - File #2 - 17
     |[29]   |                                                             |                                        19
     |       |                                                             |                    -]/[- - File #2 - 16
     |SYSTEM |                                                             |MV-2 MINUTE
     |OFF (RESET) /RUN                                                     |COUNTER
     |OFF (RESET) RUN                                                      |MV-2_MIN_COUNT
     |  I:0.0|                                                             |  C5:2      |C5:2 - CTU - File #2 - 18
     +--]/[--+                                                             +--[RES]-----|       RES - File #2 - 29
         0                                                                 |            |C5:2.DN - -] [- - File #2 - 20
       L40A                                                                |                                        22
                                                                           |                    -]/[- - File #2 - 19
                                                                           |MV-3 MINUTE
                                                                           |COUNTER
                                                                           |MV-3_MIN_COUNT
                                                                           |  C5:3      |C5:3 - CTU - File #2 - 21
                                                                           +--[RES]-----|       RES - File #2 - 29
                                                                           |            |C5:3.DN - -] [- - File #2 - 23
                                                                           |MV-4 MINUTE                             25
                                                                           |COUNTER             -]/[- - File #2 - 22
                                                                           |MV-4_MIN_COUNT
                                                                           |  C5:4      |C5:4 - CTU - File #2 - 24
                                                                           +--[RES]-----|       RES - File #2 - 29
                                                                           |            |C5:4.DN - -] [- - File #2 - 26
                                                                           |MV-5 MINUTE                             28
                                                                           |COUNTER             -]/[- - File #2 - 25
                                                                           |MV-5_MIN_COUNT
                                                                           |  C5:5      |C5:5 - CTU - File #2 - 27
                                                                           +--[RES]-----|       RES - File #2 - 29
                                                                           |            |C5:5.DN - -] [- - File #2 - 29
                                                                           |MV-1 MINUTE           -]/[- - File #2 - 28
                                                                           |TIMER
                                                                           |MV-1_TIMER
                                                                           |  T4:1      |T4:1 - TON - File #2 - 14
                                                                           +--[RES]-----|       RES - File #2 - 29 ...

 T4:1.DN - -] [- - File #2 - 15
           -]/[- - File #2 - 14
                                                                      VP-1 SEQUENCE
 SYSTEM                                                               START DELAY
 OFF (RESET) /RUN                                                     TIMER
 OFF (RESET) RUN                                                      VP-1_SEQ_START
    I:0.0                                                             +-TON---------------+   |T4:8.DN - -] [- - File #2 - 31
30|---] [-------------------------------------------------------------|Timer On Delay     |-(EN)-
       0                                                              |Timer         T4:8 |-(DN)
     L40A                                                             |Time Base     0.01 |
                                                                      |Preset         200 |
                                                                      |Accum            0 |
                                                                      +-------------------+
```

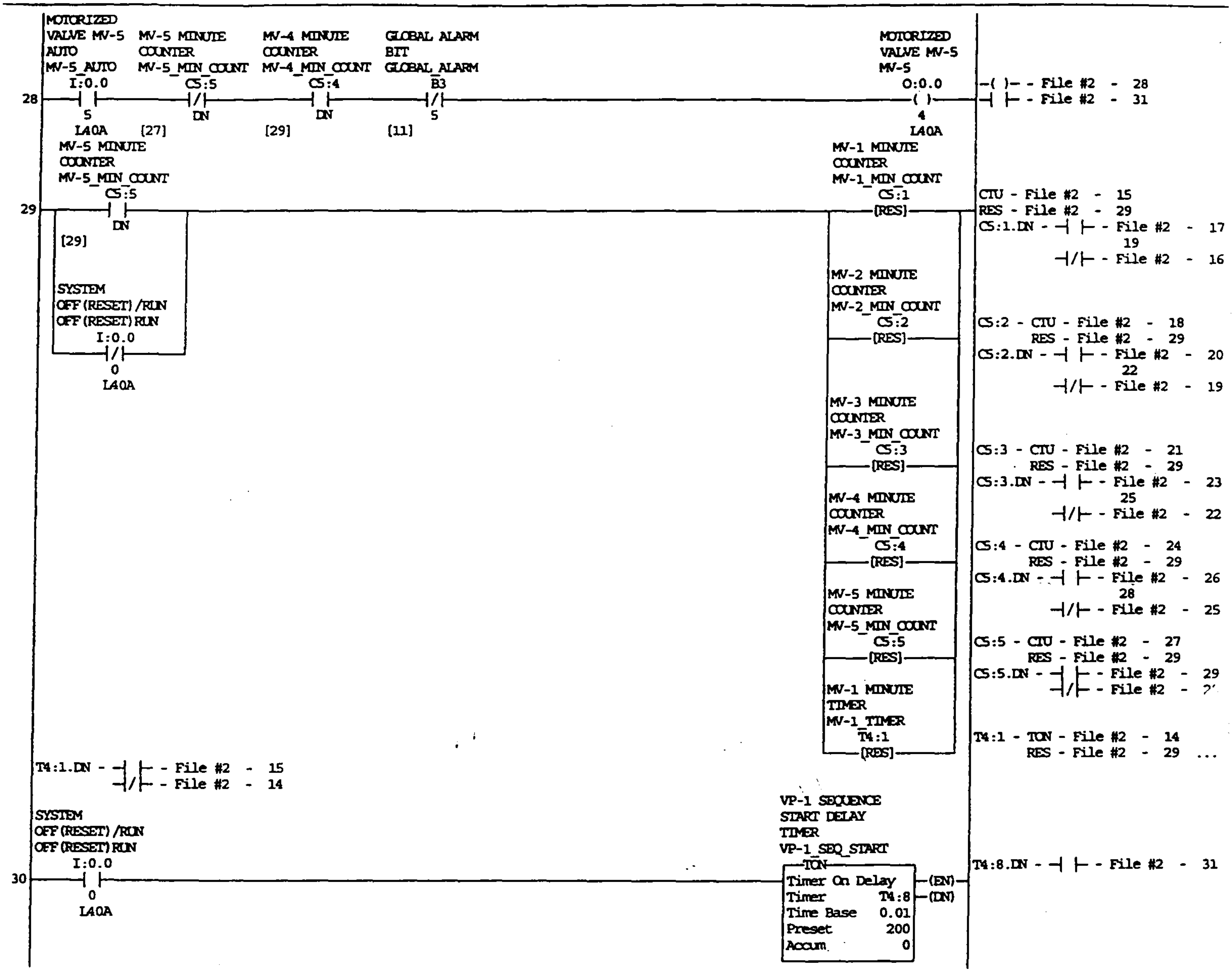
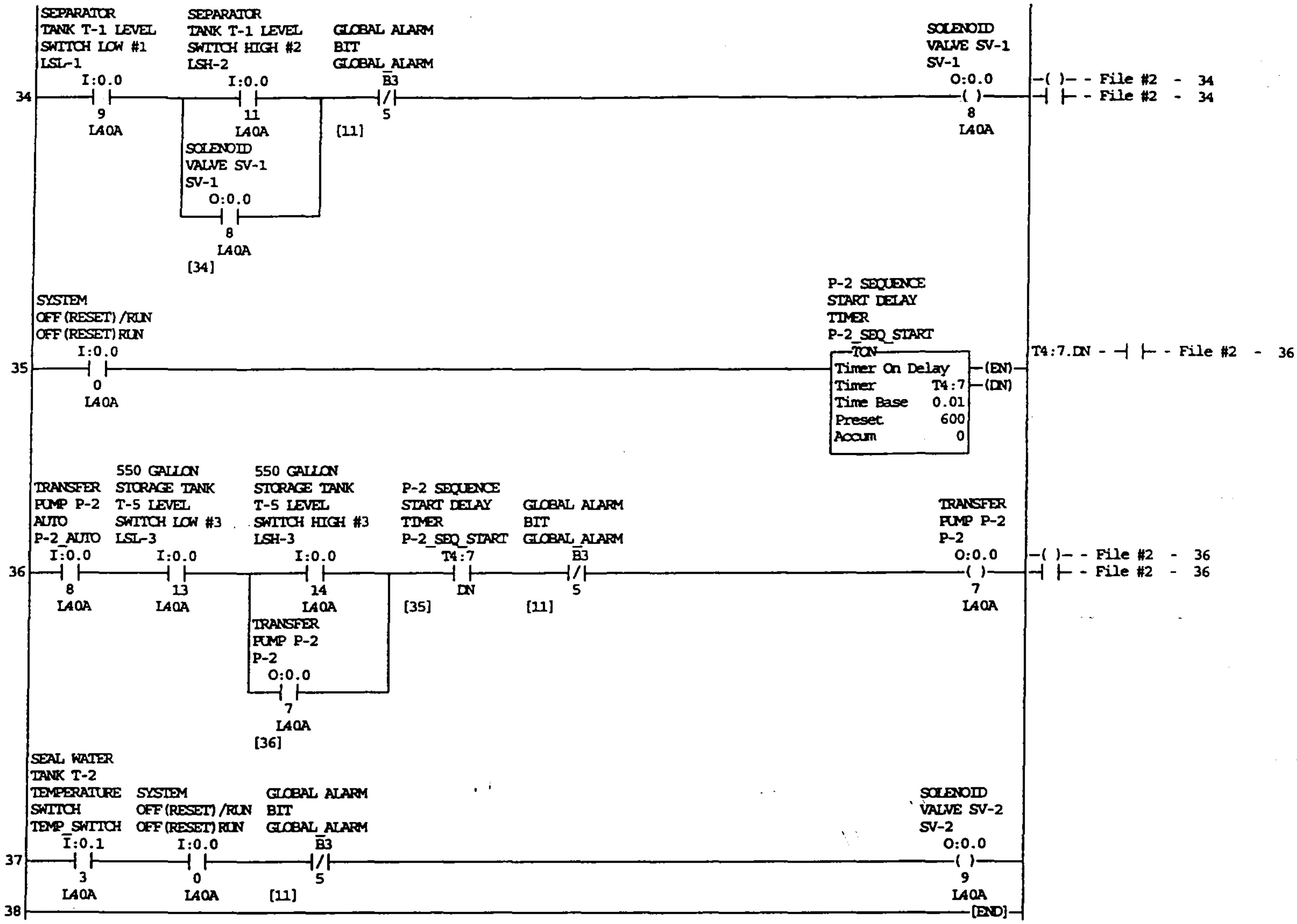

28
MOTORIZED VALVE MV-5 AUTO
MV-5_AUTO
I:0.0
5
L40A
MV-5 MINUTE COUNTER
MV-5_MIN_COUNT
C5:5
DN
[27]
MV-4 MINUTE COUNTER
MV-4_MIN_COUNT
C5:4
DN
[29]
GLOBAL ALARM BIT
GLOBAL_ALARM
B3
5
[11]
MOTORIZED VALVE MV-5
MV-5
O:0.0
4
L40A
-( )- - File #2 - 28
-| |- - File #2 - 31
29
MV-5 MINUTE COUNTER
MV-5_MIN_COUNT
C5:5
DN
[29]
SYSTEM OFF(RESET)/RUN
OFF(RESET)RUN
I:0.0
0
L40A
MV-1 MINUTE COUNTER
MV-1_MIN_COUNT
C5:1
(RES)
CTU - File #2 - 15
RES - File #2 - 29
C5:1.DN - -| |- - File #2 - 17
19
-|/|- - File #2 - 16
MV-2 MINUTE COUNTER
MV-2_MIN_COUNT
C5:2
(RES)
C5:2 - CTU - File #2 - 18
RES - File #2 - 29
C5:2.DN - -| |- - File #2 - 20
22
-|/|- - File #2 - 19
MV-3 MINUTE COUNTER
MV-3_MIN_COUNT
C5:3
(RES)
C5:3 - CTU - File #2 - 21
RES - File #2 - 29
C5:3.DN - -| |- - File #2 - 23
25
-|/|- - File #2 - 22
MV-4 MINUTE COUNTER
MV-4_MIN_COUNT
C5:4
(RES)
C5:4 - CTU - File #2 - 24
RES - File #2 - 29
C5:4.DN - -| |- - File #2 - 26
28
-|/|- - File #2 - 25
MV-5 MINUTE COUNTER
MV-5_MIN_COUNT
C5:5
(RES)
C5:5 - CTU - File #2 - 27
RES - File #2 - 29
C5:5.DN - -| |- - File #2 - 29
-|/|- - File #2 - 2'
MV-1 MINUTE TIMER
MV-1_TIMER
T4:1
(RES)
T4:1 - TON - File #2 - 14
RES - File #2 - 29 ...
T4:1.DN - -| |- - File #2 - 15
-|/|- - File #2 - 14
30
SYSTEM OFF(RESET)/RUN
OFF(RESET)RUN
I:0.0
0
L40A
VP-1 SEQUENCE START DELAY TIMER
VP-1_SEQ_START
TON
Timer On Delay
Timer T4:8
Time Base 0.01
Preset 200
Accum 0
(EN)
(DN)
T4:8.DN - -| |- - File #2 - 31

Table of Contents


34
SEPARATOR TANK T-1 LEVEL SWITCH LOW #1
LSL-1
I:0.0
9
L40A
SEPARATOR TANK T-1 LEVEL SWITCH HIGH #2
LSH-2
I:0.0
11
L40A
GLOBAL ALARM BIT
GLOBAL_ALARM
B3
5
[11]
SOLENOID VALVE SV-1
SV-1
O:0.0
8
L40A
[34]
SOLENOID VALVE SV-1
SV-1
O:0.0
8
L40A
-( )- - File #2 - 34
-| |- - File #2 - 34
35
SYSTEM OFF(RESET)/RUN
OFF(RESET)RUN
I:0.0
0
L40A
P-2 SEQUENCE START DELAY TIMER
P-2_SEQ_START
TON
Timer On Delay
Timer T4:7
Time Base 0.01
Preset 600
Accum 0
(EN)
(DN)
T4:7.DN - -| |- - File #2 - 36
36
TRANSFER PUMP P-2 AUTO
P-2_AUTO
I:0.0
8
L40A
550 GALLON STORAGE TANK T-5 LEVEL SWITCH LOW #3
LSL-3
I:0.0
13
L40A
550 GALLON STORAGE TANK T-5 LEVEL SWITCH HIGH #3
LSH-3
I:0.0
14
L40A
TRANSFER PUMP P-2
P-2
O:0.0
7
L40A
[36]
P-2 SEQUENCE START DELAY TIMER
P-2_SEQ_START
T4:7
DN
[35]
GLOBAL ALARM BIT
GLOBAL_ALARM
B3
5
[11]
TRANSFER PUMP P-2
P-2
O:0.0
7
L40A
-( )- - File #2 - 36
-| |- - File #2 - 36
37
SEAL WATER TANK T-2 TEMPERATURE SWITCH
TEMP_SWITCH
I:0.1
3
L40A
SYSTEM OFF(RESET)/RUN
OFF(RESET)RUN
I:0.0
0
L40A
GLOBAL ALARM BIT
GLOBAL_ALARM
B3
5
[11]
SOLENOID VALVE SV-2
SV-2
O:0.0
9
L40A
38
[END]

Slot:0	Slot:1	Slot:2
500 Processor	O:1.0/0 LSHH-5_ALM_LAMP LSHH-5 ALARM LAMP	
	O:1.0/1 WARNING_BEACON WARNING BEACON	
	O:1.0/2 SYS_OFF_LAMP SYSTEM OFF LAMP	
	O:1.0/3	
	O:1.0/4	
	O:1.0/5	
	O:1.0/6	
	O:1.0/7 ALM_OUT_DIALER ALARM OUTPUT TO AUTODIALER	

Rack #0 TYPE:1746-A2

Slot:0	Card:1747-L40A
Slot:1	Card:1746-OX8
Slot:2	Card:

```
B3/2     - {LSHH-3\6_ALARM}LSHH-3/LSHH-6 ALARM BIT
           0,/3,/5,7-8,/9,/11
B3/3     - {LSHH-4_ALARM}LSHH-4 ALARM BIT
           0,/3,/5-/7,9,10,/11
B3/4     - {LSHH-5_ALARM}LSHH-5 ALARM BIT
           0,/3,/5-/7,/9,11,12
B3/5     - {GLOBAL_ALARM}GLOBAL ALARM BIT
           0,3,5,7-9,11,13,/16,/19,/22,/25,/28,/31,/33,/34,/36,/37
T4:1     - {MV-1_TIMER}MV-1 MINUTE TIMER
           14,29
T4:1.DN  - MV-1 MINUTE TIMER
           /14,15
T4:2     - {MV-2_TIMER}MV-2 MINUTE TIMER
           17
T4:2.DN  - MV-2 MINUTE TIMER
           /17,18
T4:3     - {MV-3_TIMER}MV-3 MINUTE TIMER
           20
T4:3.DN  - MV-3 MINUTE TIMER
           /20,21
T4:4     - {MV-4_TIMER}MV-4 MINUTE TIMER
           23
T4:4.DN  - MV-4 MINUTE TIMER
           /23,24
T4:5     - {MV-5_TIMER}MV-5 MINUTE TIMER
           26
T4:5.DN  - MV-5 MINUTE TIMER
           /26,27
T4:6     - {P-1_SEQ_START}P-1 SEQUENCE START DELAY TIMER
           32
T4:6.DN  - P-1 SEQUENCE START DELAY TIMER
           33
T4:7     - {P-2_SEQ_START}P-2 SEQUENCE START DELAY TIMER
           35
T4:7.DN  - P-2 SEQUENCE START DELAY TIMER
           36
T4:8     - {VP-1_SEQ_START}VP-1 SEQUENCE START DELAY TIMER
           30
T4:8.DN  - VP-1 SEQUENCE START DELAY TIMER
           31
C5:1     - {MV-1_MIN_COUNT}MV-1 MINUTE COUNTER
           15,29
C5:1.DN  - MV-1 MINUTE COUNTER
           /16,17,19
C5:2     - {MV-2_MIN_COUNT}MV-2 MINUTE COUNTER
           18,29
C5:2.DN  - MV-2 MINUTE COUNTER
           /19,20,22
C5:3     - {MV-3_MIN_COUNT}MV-3 MINUTE COUNTER
           21,29
C5:3.DN  - MV-3 MINUTE COUNTER
           /22,23,25
C5:4     - {MV-4_MIN_COUNT}MV-4 MINUTE COUNTER
           24,29
C5:4.DN  - MV-4 MINUTE COUNTER
           /25,26,28
C5:5     - {MV-5_MIN_COUNT}MV-5 MINUTE COUNTER
           27,29
C5:5.DN  - MV-5 MINUTE COUNTER
           /28,29
```

I/O Point	I/O (Symbol) Description	Device Description	Upper DES	Lower DES

Data File #0 Type:O Output Elements:2 Words:2

ddress	15 ---- Data ---- 0	Address	15 ---- Data ---- 0	Address	15 ---- Data ---- 0
:0.0	0000 0000 0000 0000	O:1.0	0000 0000		

Data File #1 Type:I Input Elements:2 Words:2

ddress	15 ---- Data ---- 0	Address	15 ---- Data ---- 0	Address	15 ---- Data ---- 0
:0.0	0000 0000 0000 0000	I:0.1	0000 0000		

Data File #3 Type:B Binary Elements:1 Words:1

ddress	15 ---- Data ---- 0	Address	15 ---- Data ---- 0	Address	15 ---- Data ---- 0
3/00000	0000 0000 0000 0000				

Data File #4 Type:T Timer Elements:9 Words:27

ddress	EN	TT	DN	BASE	PRE	ACC
4:0	0	0	0	.01	0	0
4:1	0	0	0	.01	6000	0
4:2	0	0	0	.01	6000	0
4:3	0	0	0	.01	6000	0
4:4	0	0	0	.01	6000	0
4:5	0	0	0	.01	6000	0
4:6	0	0	0	.01	400	0
4:7	0	0	0	.01	600	0
4:8	0	0	0	.01	200	0

Data File #5 Type:C Counter Elements:6 Words:18

ddress	CU	CD	DN	OV	UN	UA	HP	LP	IV	IN	IH	IL	PE	LS	IE	PRE	ACC
5:0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0
5:2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	0
5:3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	0
5:4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	120	0
5:5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	0

Data File #6 Type:R Control Elements:1 Words:3

ddress	EN	EU	DN	EM	ER	UL	IN	FD	LEN	POS
6:0	0	0	0	0	0	0	0	0	0	0

Data File #7 Type:N Integer Elements:1 Words:1

ddress	0	1	2	3	4	5	6	7	8	9
7:0	0									

Slot	Part #	Card Description
	747-IA0A	24-115 VAC Inputs, 16-RLY Outputs
1	1746-OX8	8 pt Isolated Relay Output

O:0.0						
O:0.0/0	MV-1	MOTORIZED	VALVE MV-1			
O:0.0/1	MV-2	MOTORIZED	VALVE MV-2			
O:0.0/2	MV-3	MOTORIZED	VALVE MV-3			
O:0.0/3	MV-4	MOTORIZED	VALVE MV-4			
O:0.0/4	MV-5	MOTORIZED	VALVE MV-5			
O:0.0/5	VP-1	VACUUM	PUMP VP-1			
O:0.0/6	P-1	TRANSFER	PUMP P-1			
O:0.0/7	P-2	TRANSFER	PUMP P-2			
O:0.0/8	SV-1	SOLENOID	VALVE SV-1			
O:0.0/9	SV-2	SOLENOID	VALVE SV-2			
O:0.0/10	SYS_RUN_LAMP	SYSTEM RUN	LAMP			
O:0.0/11						
O:0.0/12	LSHH-1_ALM_LAMP	LSHH-1 ALARM	LAMP			
O:0.0/13	LSHH-2_ALM_LAMP	LSHH-2 ALARM	LAMP			
O:0.0/14	LSHH-3_ALM_LAMP	LSHH-3 ALARM	LAMP			
O:0.0/15	LSHH-4_ALM_LAMP	LSHH-4 ALARM	LAMP			
O:1.0						
O:1.0/0	LSHH-5_ALM_LAMP	LSHH-5 ALARM	LAMP			
O:1.0/1	WARNING_BEACON	WARNING BEACON				
O:1.0/2	SYS_OFF_LAMP	SYSTEM OFF	LAMP			
O:1.0/7	ALM_OUT_DIALER	ALARM OUTPUT	TO AUTODIALER			
I:0.0						
I:0.0/0	OFF(RESET)RUN	SYSTEM	OFF(RESET)/RUN			
I:0.0/1	MV-1_AUTO	MOTORIZED	VALVE MV-1	AUTO		
I:0.0/2	MV-2_AUTO	MOTORIZED	VALVE MV-2	AUTO		
I:0.0/3	MV-3_AUTO	MOTORIZED	VALVE MV-3	AUTO		
I:0.0/4	MV-4_AUTO	MOTORIZED	VALVE MV-4	AUTO		
I:0.0/5	MV-5_AUTO	MOTORIZED	VALVE MV-5	AUTO		
I:0.0/6	VP-1_AUTO	VACUUM	PUMP VP-1	AUTO		
I:0.0/7	P-1_AUTO	TRANSFER	PUMP P-1	AUTO		
I:0.0/8	P-2_AUTO	TRANSFER	PUMP P-2	AUTO		
I:0.0/9	LSL-1	SEPARATOR	TANK T-1 LEVEL	SWITCH LOW #1		
I:0.0/10	LSH-1	SEPARATOR	TANK T-1 LEVEL	SWITCH HIGH #1		
I:0.0/11	LSH-2	SEPARATOR	TANK T-1 LEVEL	SWITCH HIGH #2		
I:0.0/12	LSHH-1	SEPARATOR	TANK T-1 LEVEL	SWITCH HI-HI #1		
I:0.0/13	LSL-3	550 GALLON	STORAGE TANK	T-5 LEVEL	SWITCH LOW #3	
I:0.0/14	LSH-3	550 GALLON	STORAGE TANK	T-5 LEVEL	SWITCH HIGH #3	
I:0.0/15	LSHH-4	550 GALLON	STORAGE TANK	T-5 LEVEL	SWITCH HI-HI #4	
I:0.1						
I:0.1/0	LSHH-2	SEAL WATER	TANK T-2 LEVEL	SWITCH HI-HI #2		
I:0.1/2	LSHH-5	5000 GALLON	STORAGE TANK	T-6 LEVEL	SWITCH HI-HI #5	
I:0.1/3	TEMP_SWITCH	SEAL WATER	TANK T-2	TEMPERATURE	SWITCH	
I:0.1/4	LSHH-3\LSHH-6	LEVEL SWITCH	HI-HI #3	(TANK T-4) OR	#6 (SUMP)	
S:0		Arithmetic	Flags			
S:0/0		Processor	Arithmetic	Carry	Flag	
S:0/1		Processor	Arithmetic	Underflow/	Overflow	Flag
S:0/2		Processor	Arithmetic	Zero	Flag	
S:0/3		Processor	Arithmetic	Sign	Flag	
S:0/10		Primary	Protocol	Bit	0=DF1	1=DH-485
S:0/11		Active	Protocol	Bit	0=DF1	1=DH-485
S:1		Processor	Mode	Status/	Control	
S:1/0		Processor	Mode	Bit 0		
S:1/1		Processor	Mode	Bit 1		
S:1/2		Processor	Mode	Bit 2		
S:1/3		Processor	Mode	Bit 3		
S:1/4		Processor	Mode	Bit 4		
S:1/5		Forces	Enabled			
S:1/6		Forces	Present			
S:1/7		Comms	Active			
S:1/8		Fault	Override	at Powerup		
S:1/9		Startup	Protection	Fault		
S:1/10		Load	Memory	Module on	Memory	Error
S:1/11		Load	Memory	Module	Always	
S:1/12		Load	Memory	Module	and RUN	
S:1/13		Major	Error	Halted		
S:1/14		Access	Denied			
S:1/15		First Pass				
S:2/0		STI	Pending			
S:2/1		STI	Enabled			
S:2/2		STI	Executing			
S:2/3		Index	Addressing	File Range		
S:2/4		Saved with	Debug	Single	Step	
S:2/5		DH-485	Incoming	Command	Pending	
S:2/6		DH-485	Message	Reply	Pending	
S:2/7		DH-485	Outgoing	Message	Command	Pending
S:2/15		Comms	Servicing	Selection		
S:3		Current	Scan Time/	Watchdog	Scan Time	

B3/	TIMER_RESET	END OF TIMING	SEQUENCE RESET	BIT		
B						
O:						
S:0		Arithmetic	Flags			
S:0/0		Processor	Arithmetic	Carry	Flag	
S:0/1		Processor	Arithmetic	Underflow/	Overflow	Flag
S:0/2		Processor	Arithmetic	Zero	Flag	
S:0/3		Processor	Arithmetic	Sign	Flag	
S:0/10		Primary	Protocol	Bit	0=DF1	1=DH-485
S:0/11		Active	Protocol	Bit	0=DF1	1=DH-485
S:1		Processor	Mode	Status/	Control	
S:1/0		Processor	Mode	Bit 0		
S:1/1		Processor	Mode	Bit 1		
S:1/2		Processor	Mode	Bit 2		
S:1/3		Processor	Mode	Bit 3		
S:1/4		Processor	Mode	Bit 4		
S:1/5		Forces	Enabled			
S:1/6		Forces	Present			
S:1/7		Comms	Active			
S:1/8		Fault	Override	at Powerup		
S:1/9		Startup	Protection	Fault		
S:1/10		Load	Memory	Module on	Memory	Error
S:1/11		Load	Memory	Module	Always	
S:1/12		Load	Memory	Module	and RUN	
S:1/13		Major	Error	Halted		
S:1/14		Access	Denied			
S:1/15		First Pass				
S:2/0		STI	Pending			
S:2/1		STI	Enabled			
S:2/2		STI	Executing			
S:2/3		Index	Addressing	File Range		
S:2/4		Saved with	Debug	Single	Step	
S:2/5		DH-485	Incoming	Command	Pending	
S:2/6		DH-485	Message	Reply	Pending	
S:2/7		DH-485	Outgoing	Message	Command	Pending
S:2/15		Comms	Servicing	Selection		
S:3		Current	Scan Time/	Watchdog	Scan Time	
S:4		Time Base				
S:		Overflow	Trap			
S:		Control	Register	Error		
S:5/3		Major Err	Detected	Executing	UserFault	Routine
S:5/4		M0-M1	Referenced	on	Disabled	Slot
S:5/8		Memory	Module	Boot		
S:5/9		Memory	Module	Password	Mismatch	
S:5/10		STI	Overflow			
S:5/11		Battery	Low			
S:6		Major	Error	Fault	Code	
S:7		Suspend	Code			
S:8		Suspend	File			
S:9		Active	Nodes			
S:10		Active	Nodes			
S:11		I/O Slot	Enables			
S:12		I/O Slot	Enables			
S:13		Math	Register			
S:14		Math	Register			
S:15		Node	Address/	Baud Rate		
S:16		Debug	Single	Step Rung		
S:17		Debug	Single	Step File		
S:18		Debug	Single	Step	Breakpoint	Rung
S:19		Debug	Single	Step	Breakpoint	File
S:20		Debug	Fault/	Powerdown	Rung	
S:21		Debug	Fault/	Powerdown	File	
S:22		Maximum	Observed	Scan Time		
S:23		Average	Scan Time			
S:24		Index	Register			
S:25		I/O	Interrupt	Pending		
S:26		I/O	Interrupt	Pending		
S:27		I/O	Interrupt	Enabled		
S:28		I/O	Interrupt	Enabled		
S:29		User Fault	Routine	File	Number	
S:30		STI	Setpoint			
S:31		STI File	Number			
S:32		I/O	Interrupt	Executing		
S:33		Extended	Proc	Status	Control	Word
S:33/		Incoming	Command	Pending		
S:		Message	Reply	Pending		
S:		Outgoing	Message	Command	Pending	
S:33/		Selection	Status	User/DF1		

S:52		Discrete	Input	Interrupt-	Accumulat	
S:53		Discrete	Input	Interrupt-	Timer	
S:54		Discrete	Input	Interrupt-	Timer	
S:55		Last Dll	Scan	Time		
S:56		Maximum	Observed	Dll	Scan Time	
S:57		Operating	System	Catalog	Number	
S:58		Operating	System	Series		
S:59		Operating	System FRN			
S:61		Processor	Series			
S:62		Processor	Revision			
S:63		User	Program	Type		
S:64		User	Program	Functional	Index	
S:65		User RAM	Size			
S:66		Flash	EEPROM	Size		
S:67		Channel 0	Active	Nodes		
S:68		Channel 0	Active	Nodes		
S:69		Channel 0	Active	Nodes		
S:70		Channel 0	Active	Nodes		
S:71		Channel 0	Active	Nodes		
S:72		Channel 0	Active	Nodes		
S:73		Channel 0	Active	Nodes		
S:74		Channel 0	Active	Nodes		
S:75		Channel 0	Active	Nodes		
S:76		Channel 0	Active	Nodes		
S:77		Channel 0	Active	Nodes		
S:78		Channel 0	Active	Nodes		
S:79		Channel 0	Active	Nodes		
S:80		Channel 0	Active	Nodes		
S:81		Channel 0	Active	Nodes		
S:82		Channel 0	Active	Nodes		
S:83		DH+ Active	Nodes			
S:84		DH+ Active	Nodes			
S:85		DH+ Active	Nodes			
S:86		DH+ Active	Nodes			
B3:0						
B3/0	LSHH-1_ALARM	LSHH-1 ALARM	BIT			
B3/1	LSHH-2_ALARM	LSHH-2 ALARM	BIT			
B3/2	LSHH-3\6_ALARM	LSHH-3/LSHH-6	ALARM BIT			
B3/3	LSHH-4_ALARM	LSHH-4 ALARM	BIT			
B3/4	LSHH-5_ALARM	LSHH-5 ALARM	BIT			
B3/5	GLOBAL_ALARM	GLOBAL ALARM	BIT			
B3/6	TIMER_RESET	END OF TIMING	SEQUENCE RESET	BIT		
T4:1	MV-1_TIMER	MV-1 MINUTE	TIMER			
T4:1.DN		MV-1 MINUTE	TIMER			
T4:2	MV-2_TIMER	MV-2 MINUTE	TIMER			
T4:2.DN		MV-2 MINUTE	TIMER			
T4:3	MV-3_TIMER	MV-3 MINUTE	TIMER			
T4:3.DN		MV-3 MINUTE	TIMER			
T4:4	MV-4_TIMER	MV-4 MINUTE	TIMER			
T4:4.DN		MV-4 MINUTE	TIMER			
T4:5	MV-5_TIMER	MV-5 MINUTE	TIMER			
T4:5.DN		MV-5 MINUTE	TIMER			
T4:6	P-1_SEQ_START	P-1 SEQUENCE	START DELAY	TIMER		
T4:6.DN		P-1 SEQUENCE	START DELAY	TIMER		
T4:7	P-2_SEQ_START	P-2 SEQUENCE	START DELAY	TIMER		
T4:7.DN		P-2 SEQUENCE	START DELAY	TIMER		
T4:8	VP-1_SEQ_START	VP-1 SEQUENCE	START DELAY	TIMER		
T4:8.DN		VP-1 SEQUENCE	START DELAY	TIMER		
C5:1	MV-1_MIN_COUNT	MV-1 MINUTE	COUNTER			
C5:1.DN		MV-1 MINUTE	COUNTER			
C5:2	MV-2_MIN_COUNT	MV-2 MINUTE	COUNTER			
C5:2.DN		MV-2 MINUTE	COUNTER			
C5:3	MV-3_MIN_COUNT	MV-3 MINUTE	COUNTER			
C5:3.DN		MV-3 MINUTE	COUNTER			
C5:4	MV-4_MIN_COUNT	MV-4 MINUTE	COUNTER			
C5:4.DN		MV-4 MINUTE	COUNTER			
C5:5	MV-5_MIN_COUNT	MV-5 MINUTE	COUNTER			
C5:5.DN		MV-5 MINUTE	COUNTER			

S:4		Time Base				
S:	FLASHER	FLASHER BIT	1.28 SEC			
S:		Overflow	Trap			
S:5,		Control	Register	Error		
S:5/3		Major Err	Detected	Executing	UserFault	Routine
S:5/4		M0-M1	Referenced	on	Disabled	Slot
S:5/8		Memory	Module	Boot		
S:5/9		Memory	Module	Password	Mismatch	
S:5/10		STI	Overflow			
S:5/11		Battery	Low			
S:6		Major	Error	Fault	Code	
S:7		Suspend	Code			
S:8		Suspend	File			
S:9		Active	Nodes			
S:10		Active	Nodes			
S:11		I/O Slot	Enables			
S:12		I/O Slot	Enables			
S:13		Math	Register			
S:14		Math	Register			
S:15		Node	Address/	Baud Rate		
S:16		Debug	Single	Step Rung		
S:17		Debug	Single	Step File		
S:18		Debug	Single	Step	Breakpoint	Rung
S:19		Debug	Single	Step	Breakpoint	File
S:20		Debug	Fault/	Powerdown	Rung	
S:21		Debug	Fault/	Powerdown	File	
S:22		Maximum	Observed	Scan Time		
S:23		Average	Scan Time			
S:24		Index	Register			
S:25		I/O	Interrupt	Pending		
S:26		I/O	Interrupt	Pending		
S:27		I/O	Interrupt	Enabled		
S:28		I/O	Interrupt	Enabled		
S:29		User Fault	Routine	File	Number	
S:30		STI	Setpoint			
S:31		STI File	Number			
S:32		I/O	Interrupt	Executing		
S:33		Extended	Proc	Status	Control	Word
S:33/		Incoming	Command	Pending		
S:3		Message	Reply	Pending		
S:33/		Outgoing	Message	Command	Pending	
S:33/3		Selection	Status	User/DF1		
S:33/4		Communicat	Active			
S:33/5		Communicat	Servicing	Selection		
S:33/6		Message	Servicing	Selection	Channel 0	
S:33/7		Message	Servicing	Selection	Channel 1	
S:33/8		Interrupt	Latency	Control	Flag	
S:33/9		Scan	Toggle	Flag		
S:33/10		Discrete	Input	Interrupt	Reconfigur	Flag
S:33/11		Online	Edit	Status		
S:33/12		Online	Edit	Status		
S:33/13		Scan Time	Timebase	Selection		
S:33/14		DTR	Control	Bit		
S:33/15		DTR Force	Bit			
S:34		Pass-thru	Disabled			
S:34/0		Pass-Thru	Disabled	Flag		
S:34/1		DH+ Active	Node Table	Enable	Flag	
S:34/2		Floating	Point	Math Flag		
S:35		Last 1 ms	Scan Time			
S:36		Extended	Minor	Error Bits		
S:36/8		DII Lost				
S:36/9		STI Lost				
S:36/10		Memory	Module	Data File	Overwrite	Protection
S:37		Clock	Calendar	Year		
S:38		Clock	Calendar	Month		
S:39		Clock	Calendar	Day		
S:40		Clock	Calendar	Hours		
S:41		Clock	Calendar	Minutes		
S:42		Clock	Calendar	Seconds		
S:43		STI	Interrupt	Time		
S:44		I/O Event	Interrupt	Time		
S:45		DII	Interrupt	Time		
S:46		Discrete	Input	Interrupt-	File	Number
S:47		Discrete	Input	Interrupt-	Slot	Number
S:48		Discrete	Input	Interrupt-	Bit Mask	
S:49		Discrete	Input	Interrupt-	Compare	Value
S:5		Discrete	Input	Interrupt-	Preset	
S:51		Discrete	Input	Interrupt-	Return	Number

S:33/4		Communicat	Active			
S:33/5		Communicat	Servicing	Selection		
S:33/6		Message	Servicing	Selection	Channel 0	
S:33/7		Message	Servicing	Selection	Channel 1	
S:33/8		Interrupt	Latency	Control	Flag	
S:33/9		Scan	Toggle	Flag		
S:33/10		Discrete	Input	Interrupt	Reconfigur	Flag
S:33/11		Online	Edit	Status		
S:33/12		Online	Edit	Status		
S:33/13		Scan Time	Timebase	Selection		
S:33/14		DTR	Control	Bit		
S:33/15		DTR Force	Bit			
S:34		Pass-thru	Disabled			
S:34/0		Pass-Thru	Disabled	Flag		
S:34/1		DH+ Active	Node Table	Enable	Flag	
S:34/2		Floating	Point	Math Flag		
S:35		Last 1 ms	Scan Time			
S:36		Extended	Minor	Error Bits		
S:36/8		D11 Lost				
S:36/9		STI Lost				
S:36/10		Memory	Module	Data File	Overwrite	Protection
S:37		Clock	Calendar	Year		
S:38		Clock	Calendar	Month		
S:39		Clock	Calendar	Day		
S:40		Clock	Calendar	Hours		
S:41		Clock	Calendar	Minutes		
S:42		Clock	Calendar	Seconds		
S:43		STI	Interrupt	Time		
S:44		I/O Event	Interrupt	Time		
S:45		D11	Interrupt	Time		
S:46		Discrete	Input	Interrupt-	File	Number
S:47		Discrete	Input	Interrupt-	Slot	Number
S:48		Discrete	Input	Interrupt-	Bit Mask	
S:49		Discrete	Input	Interrupt-	Compare	Value
S:50		Discrete	Input	Interrupt-	Preset	
S:51		Discrete	Input	Interrupt-	Return	Number
S:52		Discrete	Input	Interrupt-	Accumulat	
S:53		Discrete	Input	Interrupt-	Timer	
S:54		Discrete	Input	Interrupt-	Timer	
S:55		Last D11	Scan	Time		
S:56		Maximum	Observed	D11	Scan Time	
S:57		Operating	System	Catalog	Number	
S:58		Operating	System	Series		
S:59		Operating	System FRN			
S:61		Processor	Series			
S:62		Processor	Revision			
S:63		User	Program	Type		
S:64		User	Program	Functional	Index	
S:65		User RAM	Size			
S:66		Flash	EEPROM	Size		
S:67		Channel 0	Active	Nodes		
S:68		Channel 0	Active	Nodes		
S:69		Channel 0	Active	Nodes		
S:70		Channel 0	Active	Nodes		
S:71		Channel 0	Active	Nodes		
S:72		Channel 0	Active	Nodes		
S:73		Channel 0	Active	Nodes		
S:74		Channel 0	Active	Nodes		
S:75		Channel 0	Active	Nodes		
S:76		Channel 0	Active	Nodes		
S:77		Channel 0	Active	Nodes		
S:78		Channel 0	Active	Nodes		
S:79		Channel 0	Active	Nodes		
S:80		Channel 0	Active	Nodes		
S:81		Channel 0	Active	Nodes		
S:82		Channel 0	Active	Nodes		
S:83		DH+ Active	Nodes			
S:84		DH+ Active	Nodes			
S:85		DH+ Active	Nodes			
S:86		DH+ Active	Nodes			

```
        Data File #0  Type:O Output  Elements:2  Words:2

Addr..  15 ---- Data ---- 0     Address  15 ---- Data ---- 0     Address  15 ---- Data ---- 0
O:0.0    XXXX 0XXX XXXX XXXX     O:1.0               X000 0XXX

        Data File #1  Type:I Input  Elements:2  Words:2

Address  15 ---- Data ---- 0     Address  15 ---- Data ---- 0     Address  15 ---- Data ---- 0
I:0.0     XXXX XXXX XXXX XXXX     I:0.1               000X XX0X

        Data File #2  Type:S Status  Elements:16  Words:16

                             1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 4
Address   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9
-------   - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
S2:0              X

        Data File #3  Type:B Binary  Elements:1  Words:1

Address  15 ---- Data ---- 0     Address  15 ---- Data ---- 0     Address  15 ---- Data ---- 0
B3/00000  0000 0000 00XX XXXX

        Data File #4  Type:T Timer  Elements:9  Words:27

                             1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 4
Address   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9
-------   - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
T4:0        X X X X X X X X

        Data File #5  Type:C Counter  Elements:6  Words:18

                             1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 4
Address   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9
-------   - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C5:0        X X X X X

        Data File #6  Type:R Control  Elements:1  Words:3

                             1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 4
Addr      0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9
---       - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
R6:

        Data File #7  Type:N Integer  Elements:1  Words:1

                             1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 4
Address   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9
-------   - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
N7:0
```

uantity	Part #	Card Description
1	1746-OX8	8 pt Isolated Relay Output

Number of Data Files:9

No	Description	File Type			Mode	Size:Elems	Words
		0	O	Output	Global	2	2
		1	I	Input	Global	2	2
		2	S	Status	Global	16	16
		3	B	Binary	Global	1	1
		4	T	Timer	Global	9	27
		5	C	Counter	Global	6	18
		6	R	Control	Global	1	3
		7	N	Integer	Global	1	1

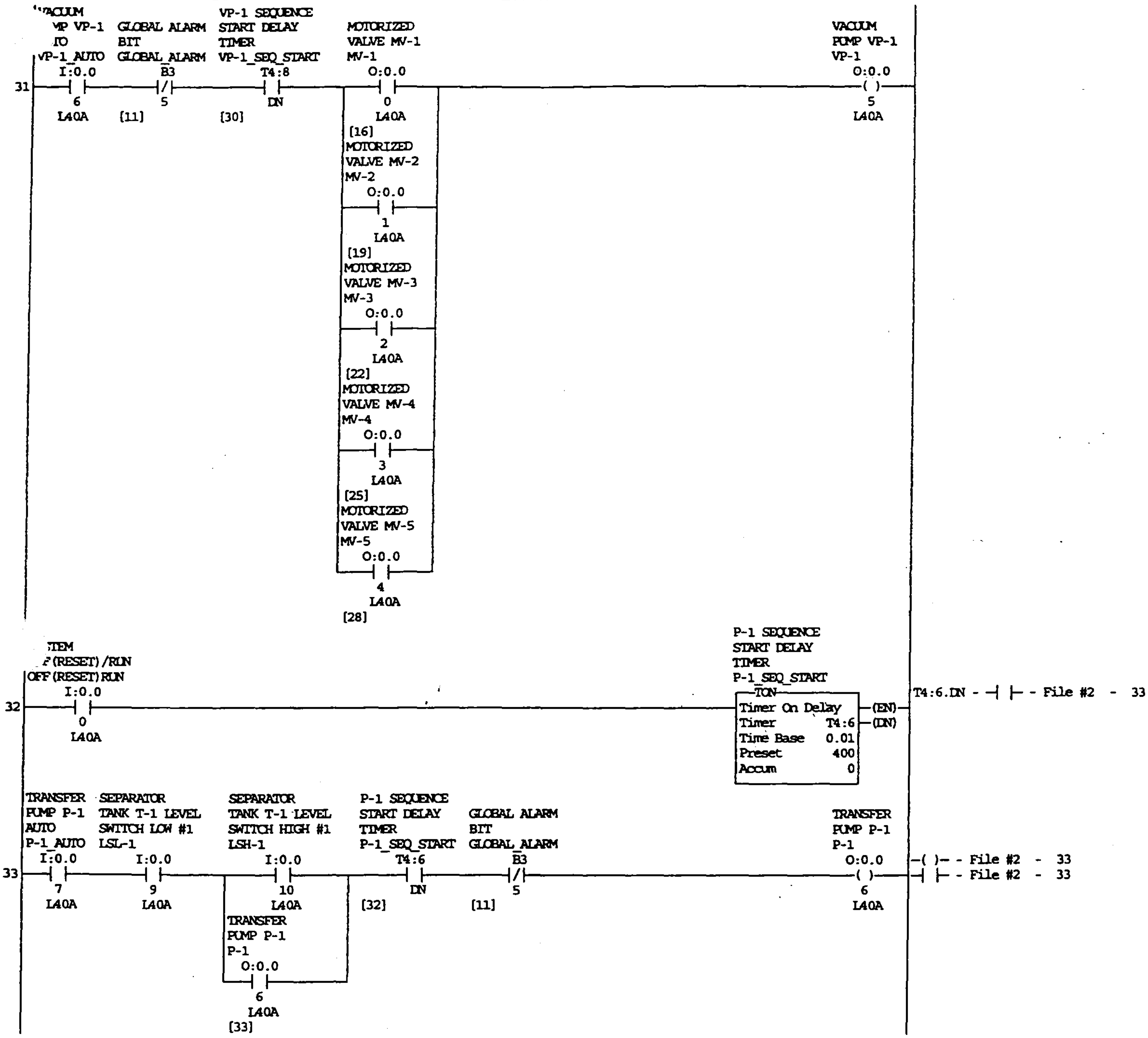
Rack #0 TYPE:1746-A2 2-Slot Backplane

Slot:	1	2
I/O Card	1746-OX8	

```
O:0.0/0    - {MV-1}MOTORIZED VALVE MV-1
             16,31
O:0.0/1    - {MV-2}MOTORIZED VALVE MV-2
             19,31
O:0.0/2    - {MV-3}MOTORIZED VALVE MV-3
             22,31
O:0.0/3    - {MV-4}MOTORIZED VALVE MV-4
             25,31
O:0.0/4    - {MV-5}MOTORIZED VALVE MV-5
             28,31
O:0.0/5    - {VP-1}VACUUM PUMP VP-1
             31
O:0.0/6    - {P-1}TRANSFER PUMP P-1
             33
O:0.0/7    - {P-2}TRANSFER PUMP P-2
             36
O:0.0/8    - {SV-1}SOLENOID VALVE SV-1
             34
O:0.0/9    - {SV-2}SOLENOID VALVE SV-2
             37
O:0.0/10   - {SYS_RUN_LAMP}SYSTEM RUN LAMP
             1
O:0.0/12   - {LSHH-1_ALM_LAMP}LSHH-1 ALARM LAMP
             4
O:0.0/13   - {LSHH-2_ALM_LAMP}LSHH-2 ALARM LAMP
             6
O:0.0/14   - {LSHH-3_ALM_LAMP}LSHH-3 ALARM LAMP
             8
O:0.0/15   - {LSHH-4_ALM_LAMP}LSHH-4 ALARM LAMP
             10
O:1.0/0    - {LSHH-5_ALM_LAMP}LSHH-5 ALARM LAMP
             12
O:1.0/1    - {WARNING_BEACON}WARNING BEACON
             13
O:1.0/2    - {SYS_OFF_LAMP}SYSTEM OFF LAMP
             2
O:1.0/7    - {ALM_OUT_DIALER}ALARM OUTPUT TO AUTODIALER
             13
I:0.0/0    - {OFF(RESET)RUN}SYSTEM OFF(RESET)/RUN
             /0,1,/2,14,/29,30,32,35,37
I:0.0/1    - {MV-1_AUTO}MOTORIZED VALVE MV-1 AUTO
             16
I:0.0/2    - {MV-2_AUTO}MOTORIZED VALVE MV-2 AUTO
             19
I:0.0/3    - {MV-3_AUTO}MOTORIZED VALVE MV-3 AUTO
             22
I:0.0/4    - {MV-4_AUTO}MOTORIZED VALVE MV-4 AUTO
             25
I:0.0/5    - {MV-5_AUTO}MOTORIZED VALVE MV-5 AUTO
             28
I:0.0/6    - {VP-1_AUTO}VACUUM PUMP VP-1 AUTO
             31
I:0.0/7    - {P-1_AUTO}TRANSFER PUMP P-1 AUTO
             33
I:0.0/8    - {P-2_AUTO}TRANSFER PUMP P-2 AUTO
             36
I:0.0/9    - {LSL-1}SEPARATOR TANK T-1 LEVEL SWITCH LOW #1
             33,34
I:0.0/10   - {LSH-1}SEPARATOR TANK T-1 LEVEL SWITCH HIGH #1
             33
I:0.0/11   - {LSH-2}SEPARATOR TANK T-1 LEVEL SWITCH HIGH #2
             34
I:0.0/12   - {LSHH-1}SEPARATOR TANK T-1 LEVEL SWITCH HI-HI #1
             3
I:0.0/13   - {LSL-3}550 GALLON STORAGE TANK T-5 LEVEL SWITCH LOW #3
             36
I:0.0/14   - {LSH-3}550 GALLON STORAGE TANK T-5 LEVEL SWITCH HIGH #3
             36
I:0.0/15   - {LSHH-4}550 GALLON STORAGE TANK T-5 LEVEL SWITCH HI-HI #4
             9
I:0.1/0    - {LSHH-2}SEAL WATER TANK T-2 LEVEL SWITCH HI-HI #2
             5
I:0.1/2    - {LSHH-5}5000 GALLON STORAGE TANK T-6 LEVEL SWITCH HI-HI #5
             11
I:0.1/3    - {TEMP_SWITCH}SEAL WATER TANK T-2 TEMPERATURE SWITCH
             37
I:0.1/4    - {LSHH-3\LSHH-6}LEVEL SWITCH HI-HI #3 (TANK T-4) OR #6 (SUMP)
             7
S:4/7      - {FLASHER}FLASHER BIT 1.28 SEC
             4,6,8,10,12
B3/0       - {LSHH-1_ALARM}LSHH-1 ALARM BIT
             0,3,4,/5,/7,/9,/11
F          - {LSHH-2_ALARM}LSHH-2 ALARM BIT
             0,/3,5,6,/7,/9,/11
```

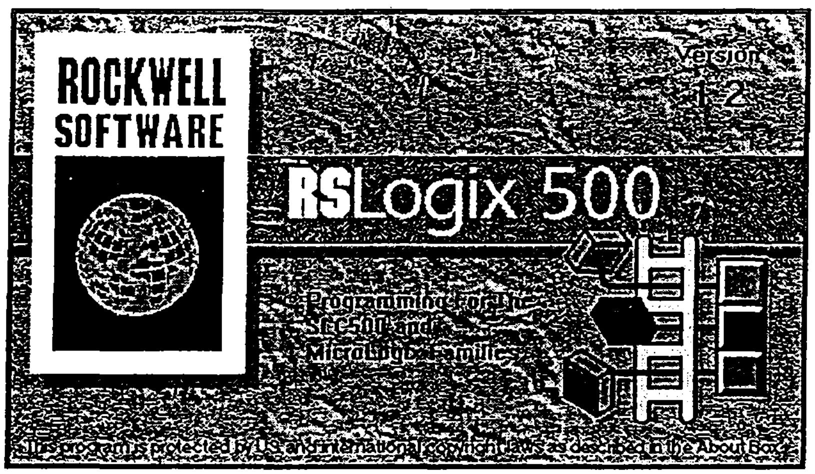
Current Program Revision # 28
PLC-500 Ladder Logistics Revision last used:v8.12

```
Rev#28   12/13/96 11:42:59 Des:
Rev#27   11/27/96 15:35:41 Des:
Rev#26   11/27/96 14:12:34 Des:
Rev#25   11/27/96 11:12:43 Des:
Rev#24   11/26/96 15:05:45 Des:
Rev#23   11/26/96 14:45:11 Des:
Rev#22   11/26/96 14:39:54 Des:
Rev#21   11/26/96 13:43:24 Des:
Rev#20   11/26/96 13:42:00 Des:
Rev#19   11/26/96 13:40:27 Des:
Rev#18   11/26/96 11:24:52 Des:
Rev#17   11/26/96 10:20:41 Des:
Rev#16   11/26/96 09:45:56 Des:
Rev#15   11/26/96 09:35:59 Des:
Rev#14   11/26/96 08:47:19 Des:
Rev#13   11/26/96 08:26:19 Des:
Rev#12   11/25/96 11:52:05 Des:
Rev#11   11/25/96 11:43:44 Des:
Rev#10   11/22/96 16:19:57 Des:
Rev#9    11/22/96 15:40:57 Des:
Rev#8    11/22/96 15:23:51 Des:
Rev#7    11/22/96 15:17:16 Des:
Rev#6    11/22/96 14:54:27 Des:
Rev#5    11/22/96 11:33:14 Des:
Rev#4    11/22/96 10:55:34 Des:
Rev#3    11/21/96 15:43:14 Des:
Rev#2    11/21/96 14:33:25 Des:
Rev#1    11/21/96 14:29:23 Des:
```


VACUUM PMP VP-1 TO VP-1_AUTO
I:0.0
6
L40A
GLOBAL ALARM BIT GLOBAL_ALARM
B3
5
[11]
VP-1 SEQUENCE START DELAY TIMER VP-1_SEQ_START
T4:8
DN
[30]
MOTORIZED VALVE MV-1 MV-1
O:0.0
0
L40A
[16]
MOTORIZED VALVE MV-2 MV-2
O:0.0
1
L40A
[19]
MOTORIZED VALVE MV-3 MV-3
O:0.0
2
L40A
[22]
MOTORIZED VALVE MV-4 MV-4
O:0.0
3
L40A
[25]
MOTORIZED VALVE MV-5 MV-5
O:0.0
4
L40A
[28]
VACUUM PUMP VP-1 VP-1
O:0.0
5
L40A
31
SYSTEM OFF (RESET)/RUN OFF(RESET)RUN
I:0.0
0
L40A
32
P-1 SEQUENCE START DELAY TIMER P-1_SEQ_START
TON
Timer On Delay
Timer T4:6
Time Base 0.01
Preset 400
Accum 0
(EN)
(DN)
T4:6.DN - File #2 - 33
TRANSFER PUMP P-1 AUTO P-1_AUTO
I:0.0
7
L40A
SEPARATOR TANK T-1 LEVEL SWITCH LOW #1 LSL-1
I:0.0
9
L40A
SEPARATOR TANK T-1 LEVEL SWITCH HIGH #1 LSH-1
I:0.0
10
L40A
TRANSFER PUMP P-1 P-1
O:0.0
6
L40A
[33]
P-1 SEQUENCE START DELAY TIMER P-1_SEQ_START
T4:6
DN
[32]
GLOBAL ALARM BIT GLOBAL_ALARM
B3
5
[11]
TRANSFER PUMP P-1 P-1
O:0.0
6
L40A
33
( ) - File #2 - 33
File #2 - 33

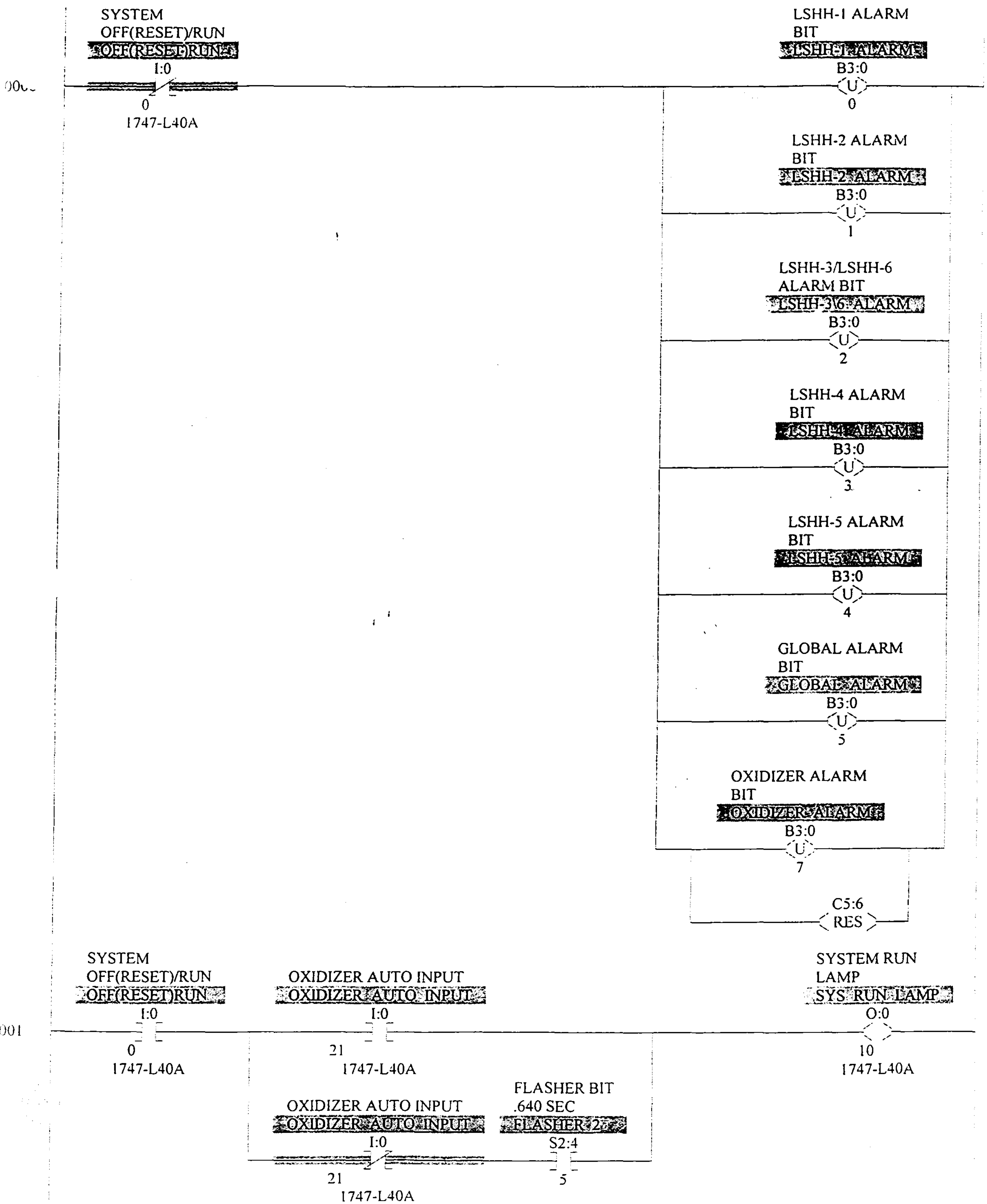
```
SLC-500 Program Information
---------------------------
Program Name.............: C:\SLC500\PROGS\AES_01\AES_01
Processor Type...........: 1747-L40A   24-115 VAC Inputs, 16-RLY Outputs
  9 Data Table Files use: 70 Words
Program Files ..........: 3
Time done printing Report: 14:51:37
Company Name.............:


Compressed Cross Reference Format Key:
--------------------------------------
#   - Xref Address used in rung #
/#  - Xref Address used in rung # as a XIO contact (-|/|-)
w#  - Xref Address used in rung # as a word.
wf# - Xref Address used in rung # as a word in a group of words used in a file
      such as being used in the 'FILE A:' parameter in a File-To-File Move Instruction.
{b} - All following xref information is for bit/subelement 'b' in the Xref Address
[f] - All following xref information is for program file # 'f'

Examples:

I:011/00 - 2,3,4     <---- Normal Rung #'s indicate usage as OTE,OTL,OTU,XIC
           /7,/8     <---- Slashes indicate usage as XIO
           w25       <---- Indicates bit address is used as a word in this rung, such as a MOV,TON,etc...

I:011/00 used as an XIC,OTE,OTL,or OTU in rungs 2,3 and 4.
        Used as an XIO (-|/|-) in rungs 7 and 8
        Used in rung 25 in a word instruction (such as a MOV)

I:010 - 5,10,15,f30 <---- Indicates address used as a word, such as in a TON,MOV,etc...
       {3},10,15    <---- Indicates a specific bit in the cross referenced word is
                          used in an OTE,OTL,OTU,XIC (or XIO if '/' precedes rung #)
       {5},23,/55   <---- Reference for address I:010 would be read as follows:

I:010 used as a word address in rungs 5,10,15 and 30, and rung 30 was a file reference.
Bit I:010/03 used in rungs 10 and 15.
Bit I:010/05 used in rungs 23 and 55, and rung 55 was an XIO (-|/|-)
```

RSLogix500 Project Report



I/O Configuration

Slot #	Part #	Description	Input Words	Output Words
	1747-L40A	24-115 VAC In, 16-RLY Out	2	1
	1746-OX8	8-Output Isolated Relay	0	1


SYSTEM
OFF(RESET)/RUN
OFF(RESET)RUN
I:0
0
1747-L40A
LSHH-1 ALARM
BIT
LSHH-1 ALARM
B3:0
U
0
LSHH-2 ALARM
BIT
LSHH-2 ALARM
B3:0
U
1
LSHH-3/LSHH-6
ALARM BIT
LSHH-3\6 ALARM
B3:0
U
2
LSHH-4 ALARM
BIT
LSHH-4 ALARM
B3:0
U
3
LSHH-5 ALARM
BIT
LSHH-5 ALARM
B3:0
U
4
GLOBAL ALARM
BIT
GLOBAL ALARM
B3:0
U
5
OXIDIZER ALARM
BIT
OXIDIZER ALARM
B3:0
U
7
C5:6
RES
001
SYSTEM
OFF(RESET)/RUN
OFF(RESET)RUN
I:0
0
1747-L40A
OXIDIZER AUTO INPUT
OXIDIZER AUTO INPUT
I:0
21
1747-L40A
OXIDIZER AUTO INPUT
OXIDIZER AUTO INPUT
I:0
21
1747-L40A
FLASHER BIT
.640 SEC
FLASHER 2
S2:4
5
SYSTEM RUN
LAMP
SYS RUN LAMP
O:0
10
1747-L40A

0(6)

OXIDIZER ALARM INPUT
OXDZR_ALM_INPUT
I:0
22
1747-L40A

OXIDIZER ALARM INPUT LOCKOUT
OXDZR_ALM_LOCKOUT
T4:9
DN

LSHH-1 ALARM BIT
LSHH-1_ALARM
B3:0
0

LSHH-2 ALARM BIT
LSHH-2_ALARM
B3:0
1

LSHH-3/LSHH-6 ALARM BIT
LSHH-3\6_ALARM
B3:0
2

LSHH-4 ALARM BIT
LSHH-4_ALARM
B3:0
3

LSHH-5 ALARM BIT
LSHH-5_ALARM
B3:0
4

OXIDIZER ALARM BIT
OXIDIZER_ALARM
B3:0
(L)
7

GLOBAL ALARM BIT
GLOBAL_ALARM
B3:0
(L)
5

0007

LSHH-1 ALARM BIT
LSHH-1_ALARM
B3:0
0

FLASHER BIT 1.28 SEC
FLASHER_1
S2:4
7

OXIDIZER ALARM BIT
OXIDIZER_ALARM
B3:0
7

FLASHER BIT .640 SEC
FLASHER_2
S2:4
5

LSHH-1 ALARM LAMP
LSHH-1_ALM_LAMP
O:0
( )
12
1747-L40A

0008

SEAL WATER TANK T-2 LEVEL SWITCH HI-HI #2
LSHH-2
I:0
16
1747-L40A

LSHH-1 ALARM BIT
LSHH-1_ALARM
B3:0
0

LSHH-3/LSHH-6 ALARM BIT
LSHH-3\6_ALARM
B3:0
2

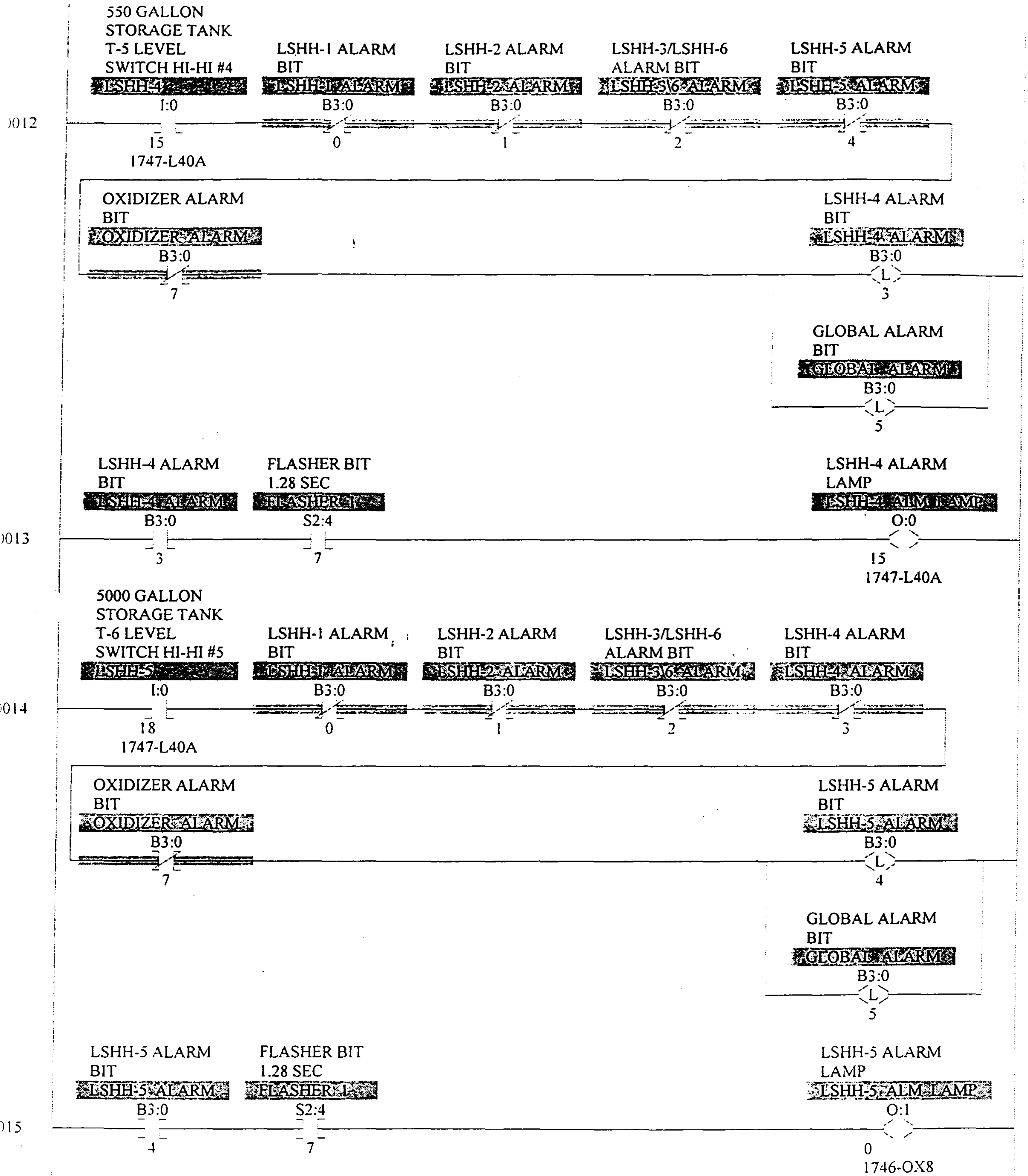
LSHH-4 ALARM BIT
LSHH-4_ALARM
B3:0
3

LSHH-5 ALARM BIT
LSHH-5_ALARM
B3:0
4

OXIDIZER ALARM BIT
OXIDIZER_ALARM
B3:0
7

LSHH-2 ALARM BIT
LSHH-2_ALARM
B3:0
(L)
1

GLOBAL ALARM BIT
GLOBAL_ALARM
B3:0
(L)
5


550 GALLON STORAGE TANK T-5 LEVEL SWITCH HI-HI #4
LSHH-4
I:0
15
1747-L40A
LSHH-1 ALARM BIT
LSHH-1 ALARM
B3:0
0
LSHH-2 ALARM BIT
LSHH-2 ALARM
B3:0
1
LSHH-3/LSHH-6 ALARM BIT
LSHH-3\6 ALARM
B3:0
2
LSHH-5 ALARM BIT
LSHH-5 ALARM
B3:0
4
0012
OXIDIZER ALARM BIT
OXIDIZER ALARM
B3:0
7
LSHH-4 ALARM BIT
LSHH-4 ALARM
B3:0
L
3
GLOBAL ALARM BIT
GLOBAL ALARM
B3:0
L
5
0013
LSHH-4 ALARM BIT
LSHH-4 ALARM
B3:0
3
FLASHER BIT 1.28 SEC
FLASHER 1
S2:4
7
LSHH-4 ALARM LAMP
LSHH-4 ALM LAMP
O:0
15
1747-L40A
0014
5000 GALLON STORAGE TANK T-6 LEVEL SWITCH HI-HI #5
LSHH-5
I:0
18
1747-L40A
LSHH-1 ALARM BIT
LSHH-1 ALARM
B3:0
0
LSHH-2 ALARM BIT
LSHH-2 ALARM
B3:0
1
LSHH-3/LSHH-6 ALARM BIT
LSHH-3\6 ALARM
B3:0
2
LSHH-4 ALARM BIT
LSHH-4 ALARM
B3:0
3
OXIDIZER ALARM BIT
OXIDIZER ALARM
B3:0
7
LSHH-5 ALARM BIT
LSHH-5 ALARM
B3:0
L
4
GLOBAL ALARM BIT
GLOBAL ALARM
B3:0
L
5
0015
LSHH-5 ALARM BIT
LSHH-5 ALARM
B3:0
4
FLASHER BIT 1.28 SEC
FLASHER 1
S2:4
7
LSHH-5 ALARM LAMP
LSHH-5 ALM LAMP
O:1
0
1746-OX8

0022
MV-1 MINUTE COUNTER — MV1_MIN_COUNT — C5:1 — DN
OXIDIZER AUTO INPUT — OXIDIZER_AUTO_INPUT — I:0 — 21 — 1747-L40A
MV-2 MINUTE TIMER — MV2_TIMER — T4:2 — DN
MV-2 MINUTE TIMER — MV-2_TIMER
TON
Timer On Delay —(EN)—
Timer T4:2
Time Base 0.01 —(DN)—
Preset 6000<
Accum 0<

0023
MV-2 MINUTE TIMER — MV2_TIMER — T4:2 — DN
MV-2 MINUTE COUNTER — MV-2_MIN_COUNT
CTU
Count Up —(CU)—
Counter C5:2
Preset 120< —(DN)—
Accum 0<

0024
MOTORIZED VALVE MV-2 AUTO — MV-2_AUTO — I:0 — 2 — 1747-L40A
MV-2 MINUTE COUNTER — MV2_MIN_COUNT — C5:2 — DN
MV-1 MINUTE COUNTER — MV1_MIN_COUNT — C5:1 — DN
GLOBAL ALARM BIT — GLOBAL_ALARM — B3:0 — 5
MOTORIZED VALVE MV-2 — MV-2 — O:0 —( )— 1 — 1747-L40A

0025
MV-2 MINUTE COUNTER — MV2_MIN_COUNT — C5:2 — DN
OXIDIZER AUTO INPUT — OXIDIZER_AUTO_INPUT — I:0 — 21 — 1747-L40A
MV-3 MINUTE TIMER — MV3_TIMER — T4:3 — DN
MV-3 MINUTE TIMER — MV-3_TIMER
TON
Timer On Delay —(EN)—
Timer T4:3
Time Base 0.01 —(DN)—
Preset 6000<
Accum 0<

0026
MV-3 MINUTE TIMER — MV3_TIMER — T4:3 — DN
MV-3 MINUTE COUNTER — MV-3_MIN_COUNT
CTU
Count Up —(CU)—
Counter C5:3
Preset 90< —(DN)—
Accum 0<

0027
MOTORIZED VALVE MV-3 AUTO — MV-3_AUTO — I:0 — 3 — 1747-L40A
MV-3 MINUTE COUNTER — MV3_MIN_COUNT — C5:3 — DN
MV-2 MINUTE COUNTER — MV2_MIN_COUNT — C5:2 — DN
GLOBAL ALARM BIT — GLOBAL_ALARM — B3:0 — 5
MOTORIZED VALVE MV-3 — MV-3 — O:0 —( )— 2 — 1747-L40A

0034

MV-5 MINUTE COUNTER
MV5 MIN COUNT
C5:5
DN

SYSTEM OFF(RESET)/RUN
OFF(RESET)RUN
I:0
0
1747-L40A

MV-1 MINUTE COUNTER
MV-1 MIN COUNT
C5:1
RES

MV-2 MINUTE COUNTER
MV-2 MIN COUNT
C5:2
RES

MV-3 MINUTE COUNTER
MV-3 MIN COUNT
C5:3
RES

MV-4 MINUTE COUNTER
MV-4 MIN COUNT
C5:4
RES

MV-5 MINUTE COUNTER
MV-5 MIN COUNT
C5:5
RES

MV-1 MINUTE TIMER
MV-1 TIMER
T4:1
RES

0035

SYSTEM OFF(RESET)/RUN
OFF(RESET)RUN
I:0
0
1747-L40A

OXIDIZER AUTO INPUT
OXIDIZER AUTO INPUT
I:0
21
1747-L40A

VP1 DELAY ON LOW TEMPERATURE S/D

TOF

Timer Off Delay	
Timer	T4:11
Time Base	0.01
Preset	12000<
Accum	0<

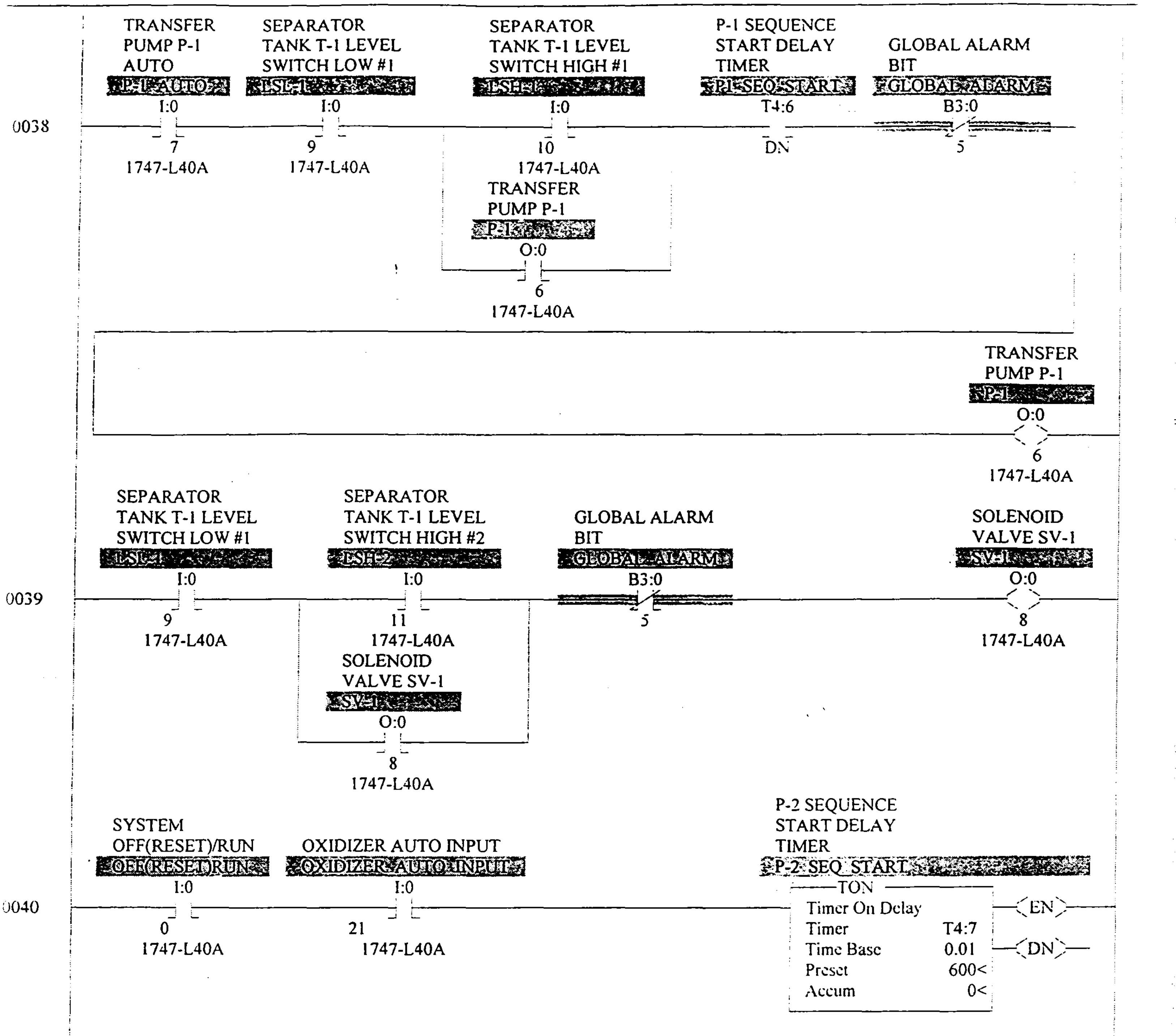
EN
DN

VP-1 SEQUENCE START DELAY TIMER
VP-1 SEQ START

TON

Timer On Delay	
Timer	T4:8
Time Base	0.01
Preset	200<
Accum	0<

EN
DN


0038
TRANSFER PUMP P-1 AUTO
P-1_AUTO
I:0
7
1747-L40A
SEPARATOR TANK T-1 LEVEL SWITCH LOW #1
LSL-1
I:0
9
1747-L40A
SEPARATOR TANK T-1 LEVEL SWITCH HIGH #1
LSH-1
I:0
10
1747-L40A
TRANSFER PUMP P-1
P-1
O:0
6
1747-L40A
P-1 SEQUENCE START DELAY TIMER
P1_SEQ_START
T4:6
DN
GLOBAL ALARM BIT
GLOBAL_ALARM
B3:0
5
TRANSFER PUMP P-1
P-1
O:0
6
1747-L40A
0039
SEPARATOR TANK T-1 LEVEL SWITCH LOW #1
LSL-1
I:0
9
1747-L40A
SEPARATOR TANK T-1 LEVEL SWITCH HIGH #2
LSH-2
I:0
11
1747-L40A
SOLENOID VALVE SV-1
SV-1
O:0
8
1747-L40A
GLOBAL ALARM BIT
GLOBAL_ALARM
B3:0
5
SOLENOID VALVE SV-1
SV-1
O:0
8
1747-L40A
0040
SYSTEM OFF(RESET)/RUN
OFF(RESET)RUN
I:0
0
1747-L40A
OXIDIZER AUTO INPUT
OXIDIZER_AUTO_INPUT
I:0
21
1747-L40A
P-2 SEQUENCE START DELAY TIMER
P-2_SEQ_START
TON
Timer On Delay
Timer T4:7
Time Base 0.01
Preset 600<
Accum 0<
EN
DN

Data File O0

Offset	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
O:0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	OTHER - I/O Module - ID Code = 2200
O:1									0	0	0	0	0	0	0	0	1746-OX8 - 8-Output Isolated Relay

Address/Symbol Database

Address	Symbol	Scope	Description	Sym Grou
B3:0				
B3:0/0	LSHH-1_ALARM	Global	LSHH-1 ALARM BIT	
B3:0/1	LSHH-2_ALARM	Global	LSHH-2 ALARM BIT	
B3:0/2	LSHH-3\6_ALARM	Global	LSHH-3/LSHH-6 ALARM BIT	
B3:0/3	LSHH-4_ALARM	Global	LSHH-4 ALARM BIT	
B3:0/4	LSHH-5_ALARM	Global	LSHH-5 ALARM BIT	
B3:0/5	GLOBAL_ALARM	Global	GLOBAL ALARM BIT	
B3:0/6	TIMER_RESET	Global	END OF TIMING SEQUENCE RESET BIT	
B3:0/7	OXIDIZER_ALARM	Global	OXIDIZER ALARM BIT	
C5:1	MV-1_MIN_COUNT	Global	MV-1 MINUTE COUNTER	
C5:1/DN	MV1_MIN_COUNT	Global	MV-1 MINUTE COUNTER	
C5:2	MV-2_MIN_COUNT	Global	MV-2 MINUTE COUNTER	
C5:2/DN	MV2_MIN_COUNT	Global	MV-2 MINUTE COUNTER	
C5:3	MV-3_MIN_COUNT	Global	MV-3 MINUTE COUNTER	
C5:3/DN	MV3_MIN_COUNT	Global	MV-3 MINUTE COUNTER	
C5:4	MV-4_MIN_COUNT	Global	MV-4 MINUTE COUNTER	
C5:4/DN	MV4_MIN_COUNT	Global	MV-4 MINUTE COUNTER	
C5:5	MV-5_MIN_COUNT	Global	MV-5 MINUTE COUNTER	
C5:5/DN	MV5_MIN_COUNT	Global	MV-5 MINUTE COUNTER	
I:0.0				
I:0/0	OFF(RESET)RUN	Global	SYSTEM OFF(RESET)/RUN	
I:0/1	MV-1_AUTO	Global	MOTORIZED VALVE MV-1 AUTO	
I:0/2	MV-2_AUTO	Global	MOTORIZED VALVE MV-2 AUTO	
I:0/3	MV-3_AUTO	Global	MOTORIZED VALVE MV-3 AUTO	
I:0/4	MV-4_AUTO	Global	MOTORIZED VALVE MV-4 AUTO	
I:0/5	MV-5_AUTO	Global	MOTORIZED VALVE MV-5 AUTO	
I:0/6	VP-1_AUTO	Global	VACUUM PUMP VP-1 AUTO	
I:0/7	P-1_AUTO	Global	TRANSFER PUMP P-1 AUTO	
I:0/8	P-2_AUTO	Global	TRANSFER PUMP P-2 AUTO	
I:0'	LSL-1	Global	SEPARATOR TANK T-1 LEVEL SWITCH LOW #1	
I:'	LSH-1	Global	SEPARATOR TANK T-1 LEVEL SWITCH HIGH #1	
I:0,.1	LSH-2	Global	SEPARATOR TANK T-1 LEVEL SWITCH HIGH #2	
I:0/12	LSHH-1	Global	SEPARATOR TANK T-1 LEVEL SWITCH HI-HI #1	
I:0/13	LSL-3	Global	550 GALLON STORAGE TANK T-5 LEVEL SWITCH LOW #3	
I:0/14	LSH-3	Global	550 GALLON STORAGE TANK T-5 LEVEL SWITCH HIGH #3	
I:0/15	LSHH-4	Global	550 GALLON STORAGE TANK T-5 LEVEL SWITCH HI-HI #4	
:0.1				
:0/16	LSHH-2	Global	SEAL WATER TANK T-2 LEVEL SWITCH HI-HI #2	
:0/17	VP1_OL	Global	VACCUM PUMP #1 OVERLOAD	
:0/18	LSHH-5	Global	5000 GALLON STORAGE TANK T-6 LEVEL SWITCH HI-HI #5	
:0/19	TEMP_SWITCH	Global	SEAL WATER TANK T-2 TEMPERATURE SWITCH	
:0/20	LSHH-3\LSHH-6	Global	LEVEL SWITCH HI-HI #3 (TANK T-4) OR #6 (SUMP)	
:0/21	OXIDIZER_AUTO_INPUT	Global	OXIDIZER AUTO INPUT	
:0/22	OXDZR_ALM_INPUT	Global	OXIDIZER ALARM INPUT	
:0.0				
:0/0	MV-1	Global	MOTORIZED VALVE MV-1	
:0/1	MV-2	Global	MOTORIZED VALVE MV-2	
:0/2	MV-3	Global	MOTORIZED VALVE MV-3	
:0/3	MV-4	Global	MOTORIZED VALVE MV-4	
:0/4	MV-5	Global	MOTORIZED VALVE MV-5	
:0/5	VP-1	Global	VACUUM PUMP VP-1	
:0/6	P-1	Global	TRANSFER PUMP P-1	
:0/7	P-2	Global	TRANSFER PUMP P-2	
:0/8	SV-1	Global	SOLENOID VALVE SV-1	
:0/9	SV-2	Global	SOLENOID VALVE SV-2	
:0/10	SYS_RUN_LAMP	Global	SYSTEM RUN LAMP	
:0/11				
:0/12	LSHH-1_ALM_LAMP	Global	LSHH-1 ALARM LAMP	
:0/13	LSHH-2_ALM_LAMP	Global	LSHH-2 ALARM LAMP	
:0/14	LSHH-3_ALM_LAMP	Global	LSHH-3 ALARM LAMP	
:0/15	LSHH-4_ALM_LAMP	Global	LSHH-4 ALARM LAMP	
:1				
:1,	LSHH-5_ALM_LAMP	Global	LSHH-5 ALARM LAMP	

Address	Symbol	Scope	Description	Sym Grou
S2:23			Average Scan Time	
S2			Index Register	
S2			I/O Interrupt Pending	
S2:26			I/O Interrupt Pending	
S2:27			I/O Interrupt Enabled	
S2:28			I/O Interrupt Enabled	
S2:29			User Fault Routine File Number	
S2:30			STI Setpoint	
S2:31			STI File Number	
S2:32			I/O Interrupt Executing	
S2:33			Extended Proc Status Control Word	
S2:33/0			Incoming Command Pending	
S2:33/1			Message Reply Pending	
S2:33/2			Outgoing Message Command Pending	
S2:33/3			Selection Status User/DF1	
S2:33/4			Communicat Active	
S2:33/5			Communicat Servicing Selection	
S2:33/6			Message Servicing Selection Channel 0	
S2:33/7			Message Servicing Selection Channel 1	
S2:33/8			Interrupt Latency Control Flag	
S2:33/9			Scan Toggle Flag	
S2:33/10			Discrete Input Interrupt Reconfigur Flag	
S2:33/11			Online Edit Status	
S2:33/12			Online Edit Status	
S2:33/13			Scan Time Timebase Selection	
S2:33/14			DTR Control Bit	
S2:33/15			DTR Force Bit	
S2:34			Pass-thru Disabled	
S2:34/0			Pass-Thru Disabled Flag	
S2:34/1			DH+ Active Node Table Enable Flag	
S2:34/2			Floating Point Math Flag	
S2:35			Last 1 ms Scan Time	
S2:3[illegible]			Extended Minor Error Bits	
S2:[illegible]			Dll Lost	
S2:[illegible]9			STI Lost	
S2:36/10			Memory Module Data File Overwrite Protection	
S2:37			Clock Calendar Year	
S2:38			Clock Calendar Month	
S2:39			Clock Calendar Day	
S2:40			Clock Calendar Hours	
S2:41			Clock Calendar Minutes	
S2:42			Clock Calendar Seconds	
S2:43			STI Interrupt Time	
S2:44			I/O Event Interrupt Time	
S2:45			Dll Interrupt Time	
S2:46			Discrete Input Interrupt- File Number	
S2:47			Discrete Input Interrupt- Slot Number	
S2:48			Discrete Input Interrupt- Bit Mask	
S2:49			Discrete Input Interrupt- Compare Value	
S2:50			Discrete Input Interrupt- Preset	
S2:51			Discrete Input Interrupt- Return Number	
S2:52			Discrete Input Interrupt- Accumulat	
S2:53			Discrete Input Interrupt- Timer	
S2:54			Discrete Input Interrupt- Timer	
2:55			Last Dll Scan Time	
2:56			Maximum Observed Dll Scan Time	
2:57			Operating System Catalog Number	
2:58			Operating System Series	
2:59			Operating System FRN	
2:61			Processor Series	
2:62			Processor Revision	
2:63			User Program Type	
2:64			User Program Functional Index	
2:65			User RAM Size	
2:[illegible]			Flash EEPROM Size	
2:[illegible]			Channel 0 Active Nodes	

Address	Instruction	Description

MISCELLANEOUS
SYSTEM COMPONENTS

RATEMASTER® FLOWMETER

Installation and Operating Instructions

DIMENSIONS & MOUNTING INFORMATION

DIMENSIONS – IN INCHES			
	RMA	RMB	RMC
A	4-5/16	8-1/2	15-1/8
B	3	6-7/16	12-1/4
	1/8 NPT CONN.	1/4 NPT CONN.	1/2 NPT CONN.
C	1-5/8"	3-15/16	8-3/4
	10-32 THDS.	1/4-20 THDS.	3/8-24 THDS.
D	3/8	5/8	1
E	1-1/16	1-7/8	2-3/4
F	1-3/16	1-3/4	2-1/4
G	11/16	1	1-7/16
H	1	1-7/16	1-31/32
I (OPEN)	1-3/8	1-13/16	2-1/2
J	3/4	1-1/4	2
K	4-13/16	8-3/4	15-3/8
L	1	1-1/2	2-1/4

PANEL CUT OUT
(FOR FLUSH MOUNTING)

HIGH	4-5/8	8-9/16	15-3/16
WIDE	7/8	1-5/16	2-1/16

PANEL HOLE SIZES
(FOR SURFACE MOUNTING)

PIPE	7/16	5/8	15/16
BOLT	1/4	9/32	13/32

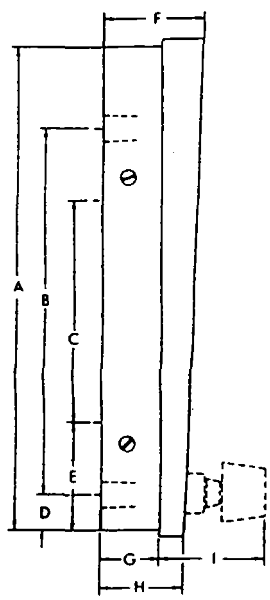


Figure 1

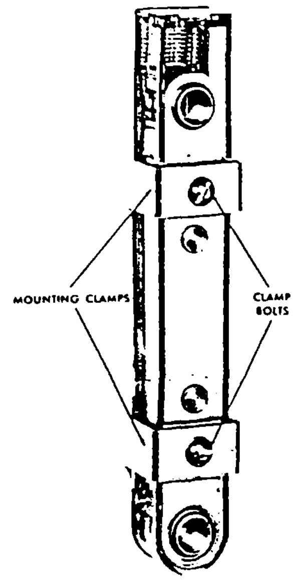


Figure 2

Dwyer Rate-Master® Series RM Flowmeters are furnished in three models (see Figure 1) each available in a broad choice of flow ranges with direct reading scales for air, gas or water. Installation, operation and maintenance are very simple and only a few common sense precautions must be observed to assure long, trouble-free service.

CAUTION

Dwyer Rate-Mater(R) flowmeters are designed to provide satisfactory long term service when used with air, water or other compatible media. Refer to factory for information on questionable gases or liquids. Avoid solutions of acids, bases or salts having a pH below 5.0 or above 8.5. Caustic solutions, anti-freeze (ethylene glycol) and aromatic solvents should definitely not be used.

CALIBRATION

Each Dwyer flowmeter is calibrated at the factory. If at any time during the meter's life, you wish to recheck its calibration, do so only with devices of certified accuracy. DO NOT attempt to check the Dwyer Rate-Master® Flowmeter with a similar flowmeter as seemingly unimportant variations in piping and back pressure may cause noticeable differences in the indicated reading. If in doubt, return your Dwyer flowmeter to the factory. It will be calibration checked for you at no charge.

Before proceeding with the installation of your Dwyer Rate-Master Flowmeter, check to be sure you have the model and flow range you require.

LOCATION

TEMPERATURE, PRESSURE, ATMOSPHERE, AND VIBRATION: Rate-Master Polycarbonate Flowmeters are exceptionally tough and strong. They are designed for use at pressures up to 100 PSI (RMB units 70 PSI, RMC 35 PSI) and temperatures up to 130 deg. F. DO NOT EXCEED THESE LIMITS! The installation should not be exposed to strong chlorine atmospheres or solvents such as benzene, acetone, carbon tetrachloride, etc. The mounting panel should be free of excessive vibration since it may prevent the unit from operating properly.

INLET PIPING RUN: It is good practice to approach the flowmeter inlet with as few elbows and restrictions as possible. In every case the inlet piping should be at least as large as the connection to the flowmeter i.e. 1/8" Iron Pipe Size for RMA, 1/4" IPS for RMB and 1/2" IPS for RMC. Length of inlet piping makes little difference for normal pressure fed flowmeters.

For flowmeters on vacuum air service the inlet piping should be as short and open as possible. This will allow operation near atmospheric pressure and thereby insure the accuracy of the device. (Note that for vacuum air service the flow control valve if any, should be on the discharge side of the flowmeter. Either the TMV unit or a separate in line valve may be applied.)

DISCHARGE PIPING: As on the inlet, discharge piping should be at least as large as the flowmeter connection. In addition, for pressure fed flowmeters on air or gas service the discharge piping should be as short and open as possible. This will allow operation of the flow tube at near atmospheric pressure and insure the accuracy of the device. This is of less importance on water or liquid flowmeters since the flowing medium is generally incompressible and moderate back pressure will not affect the accuracy of the instrument as calibrated.

POSITION AND MOUNTING

All Rate-Master Flowmeters must be mounted in a vertical position with the inlet connection at the bottom rear and outlet at top rear.

BEZEL OR THROUGH PANEL MOUNTING: Make the panel cutout using the appropriate dimensions from Figure 1. Flowmeter must fit into the panel freely without force or squeeze.

Insert the Rate-Master Flowmeter from the front of the panel and install the mounting clamps from the rear, insert and tighten the clamp bolts in the locations shown in Figure 2. Do not exceed 5 in./lbs. Make connections to inlet and outlet ports using small amount of RTV sealant or Teflon® thread tape to avoid leakage. Avoid excess torque which may damage flowmeter body.

DWYER INSTRUMENTS, INC.
P.O. BOX 373 • MICHIGAN CITY, INDIANA 46360, U.S.A.
Telephone 219/879-8000
Fax 219/872-9057 Telex 25916

RATEMASTER® FLOWMETER
Instructions

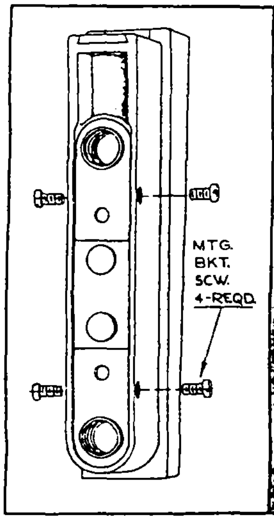


Figure 3

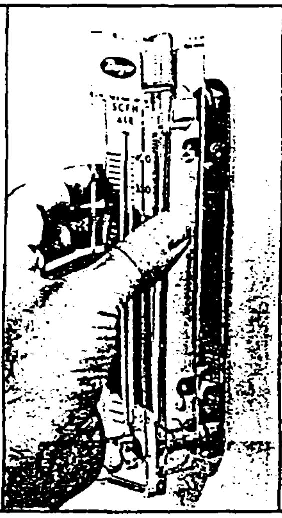


Figure 4

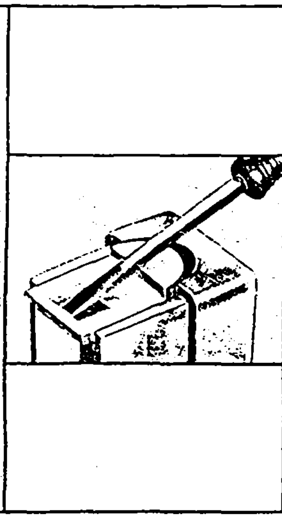


Figure 5

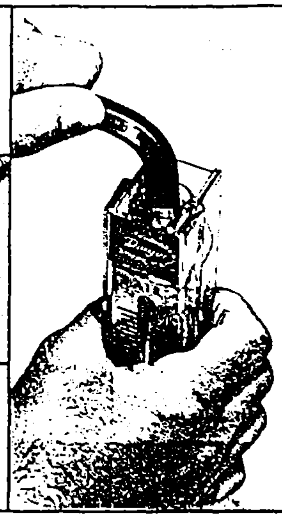


Figure 6

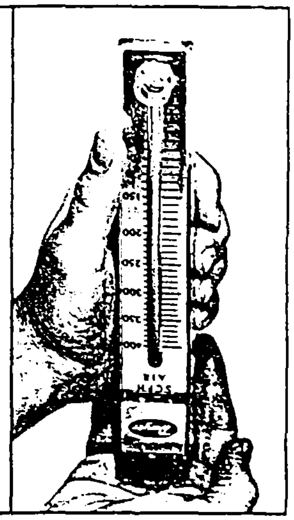


Figure 7

SURFACE MOUNTING: Drill appropriate holes in panel using the dimensions shown in Figure 1. Hold the flowmeter in position in front of the panel and install the clamp bolts through the panel from the rear. (The mounting clamps may be used as washers if desired by installing them backwards or straightening them out.) Pipe up inlet and discharge following the directions in previous sections.

SURFACE MOUNTING ON PIPING ONLY: An alternate method of surface mounting omitting the clamp bolts and supporting the Rate-Master Flowmeter on the connecting piping only is possible. For this method extra long or straight pipe threads should be used so that nuts may be run onto the pipe and later tightened against the back of the panel to retain the unit in proper position. Use the appropriate hole layout information from Figure 1, but omit the small holes.

MOUNTING ON PIPING ONLY WITHOUT PANEL: For a temporary or laboratory type installation, the panel may be omitted altogether and the flowmeter installed directly in rigid piping. Its light weight permits this without difficulty.

OPERATION

To start system, open the valve slowly to avoid possible damage. Rate of flow is read at the point of maximum horizontal width for spherical floats or at the top of the largest diameter for non-spherical floats. Control valves on BV and SSV models are turned clockwise to reduce flow, counter clockwise to increase flow. A nylon insert is provided in the threaded section of the valve stem to give a firm touch to the valve and to prevent change of setting due to vibration.

CAUTION

Do not completely unscrew valve stem unless flowmeter is unpressurized and drained of any liquid. Removal while in service will allow gas or liquid to flow out front of valve body and could result in serious personal injury. For applications involving high pressure and/or toxic gasses or fluids, special non-removable valves are available on special order. Contact factory for details.

MAINTENANCE

The only maintenance normally required is occasional cleaning to assure reliable operation and good float visibility.

DISASSEMBLY: The flowmeter can be disassembled for cleaning simply as follows:

1. Remove valve knob from RMB or RMC — BV or SSV units by pulling the knob forward. It is retained by spring pressure on the stem half-shaft so that a gentle pull will remove it. On RMA-BV or SSV models, turn the valve knob counter-clockwise until the threads are disengaged. Then withdraw the stem from the valve by gently pulling on the knob.

2. Remove the four mounting bracket screws located in the sides of the flowmeter. See Figure 3.

Pull the flowmeter body gently forward away from the back plate and pipe thread connections. Keep the body parallel with the back plate to avoid undue strain on the body. Leave the piping connections intact. There is no need to disturb them. See Figure 4.

3. Remove the slip cap with a push on a screwdriver as shown in Figure 5. Remove the plug-ball stop as shown in Figure 6 using allen wrench sizes as follows: Model RMA — 1/4", Model RMB — 1/2", and Model RMC — 3/4".

4. Take out the ball or float by inverting the body and allowing the float to fall into your hand as shown in Figure 7. (Note: It is best to cover the discharge port to avoid losing the float through that opening.)

CLEANING: The flow tube and flowmeter body can best be cleaned with a little pure soap and water. Use of a bottle brush or other soft brush will aid the cleaning. Avoid benzene, acetone, carbon tetrachloride, alkaline detergents, caustic soda, liquid soaps (which may contain chlorinated solvents), etc. and avoid prolonged immersion which may harm or loosen the scale.

REASSEMBLY: Simply reverse Steps 5A. 1 through 4 and place back in service. A little stop cock grease or petroleum jelly on the "O" rings will help maintain a good seal as well as facilitate assembly. No other special care is required.

ADDITIONAL INFORMATION

For additional flowmeter application information, conversion curves, factors and other data covering the entire line of Dwyer Rate-Master Flowmeters, send for Bulletin F-41.

56 - 440197 - 00

Litho in U.S.A. 9/88

Dwyer
DWYER INSTRUMENTS, INC.
P.O. Box 373, Michigan City, Indiana 46360, U.S.A.
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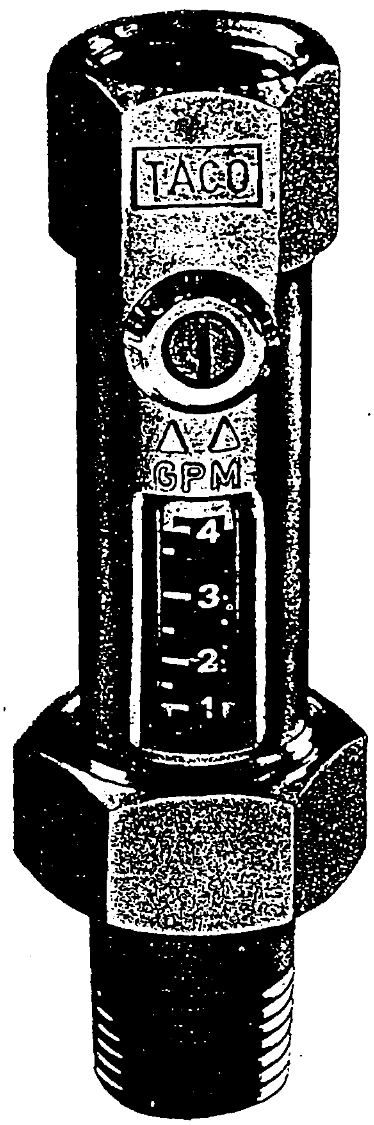
Taco

COMPARE. YOU'LL TAKE TACO.

TACO FLO-SETTER



- Direct Reading Flow-Meter
- Balancing Valve
- Shut-Off Valve
- Nickle Plated Brass
- Compact In-Line Design
- Low Pressure Drop

CATALOG 400-2.3

Supersedes: Cat. No. 100-4.5 Dated 1/15/83 Effective 6/1/92

Submittal Data Information

401-020

FLO-SETTER

SUPERSEDES: 401-020—December 18, 1987 EFFECTIVE: JUNE 1, 1992

APPLICATION

The Flo-Setter is a combination direct reading flow meter, and adjustable ball valve for balancing and shut-off. This valve is suitable for commercial hot and chilled water closed loop applications, domestic water circulation, and solar systems.

The Flo-Setter can be installed in any position, and has a directional arrow located on the body of the valve. System requirements can be fine tuned by adjusting the Flo-Setter's ball valve.

VALVE

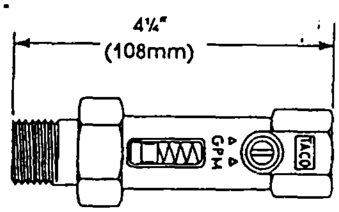
PRODUCT NUMBER	SIZE	CONNECTIONS *	FLOW RANGE	C_v
7201	½"	½" Union Nut with Gasket x ½" FPT	0.5- 2.2 GPM	2.2
7202	½"	½" Union Nut with Gasket x ½" FPT	1.0- 4.0 GPM	2.2
7205	¾"	¾" Union Nut with Gasket x ¾" Union Nut with Gasket	1.5- 5.0 GPM	5.4
7206	¾"	¾" Union Nut with Gasket x ¾" Union Nut with Gasket	2.0- 8.0 GPM	5.6

TAILPIECE AND ADAPTER

PRODUCT NUMBER	SIZE	CONNECTIONS*
7201-003	1/2"	½" NPT Tailpiece for Union End
7201-004	1/2"	½" Sweat Tailpiece for Union End
7201-005	1/2"	½" Sweat x ½" NPT Adapter for Threaded End
7205-009	3/4"	¾" NPT Tailpiece for Union Ends
7205-010	3/4"	¾" Sweat Tailpiece for Union Ends

DIMENSIONS

½" Flo-Setter

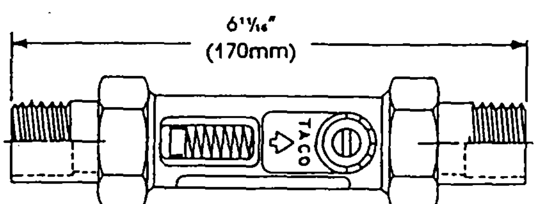


½" NPT x ½ FPT

C_v is the flow in GPM with a pressure loss of one PSI through the Flo-Setter. C_v is shown with valve fully open.

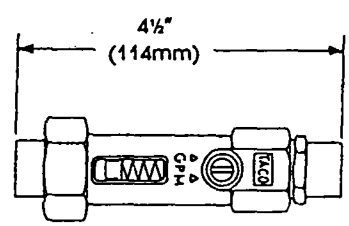
$$C_v = \frac{GPM}{\sqrt{\Delta PSI}} \qquad \Delta PSI = \left(\frac{GPM}{C_v}\right)^2$$

¾" Flo-Setter



¾" NPT x ¾" NPT
or ¾" Sweat x ¾" Sweat

½" Flo-Setter



½" Sweat x ½" Sweat

SPECIFICATIONS

Pressure	125psi Maximum
Temperature	180°F Maximum
Accuracy	±10% of Full Scale

MATERIALS

Body	Brass, Nickle Plated
Sight Glass	Polysulfone
Seals	EPDM

* NOTE: The type of tailpiece, male NPT or Sweat Connection must be selected and ordered to make a complete Flo-Setter.

COMPARE. YOU'LL TAKE TACO.

TACO, INC., 1160 Cranston Street, Cranston, RI 02920 (401) 942-8000 FAX: (401) 942-2360.

Printed in USA

Taco	INSTRUCTION SHEET
NUMBER IS100-4.5	Effective: February 1, 1983 Supersedes: IS100-4.5 dated 4/1/82

Plant ID No. 001-904

FLO-SETTER

IN-LINE FLOW METER and BALANCING VALVE 7201, 7202 7205, 7206

INSTALLATION: The Taco Flo-Setter can be placed at any location in the system. The preferred location is in a return pipe. It works reliably in any position.

FLOW SETTING: Turn the stem of the ball valve by using a screwdriver in the stem slot until the desired flow is observed at the end of the float indicator.

Stem slot in flow direction: valve is full open.

Stem slot across flow: valve is closed.

NOTE: In case of poor light or murky water, a flashlight and mirror directing the light through the sight glass is recommended.

APPLICATION DATA: Pressure rating — 125 psi max.

Temperature rating — 210°F max. (continuous)

The Flo-Setter can withstand exposure to water as hot as 300°F for a few minutes as might occur in a static situation in a solar system.

Accuracy — ± 10% of full scale.

Acceptable Fluids

Water, mixtures of water and ethylene glycol or propylene glycol, solar fluids not containing hydrocarbons.

TO CHANGE FILTER CARTRIDGES

1. Turn off water supply to filter. If unit is Valve-In-Head style, rotate handle on top of housing to OFF position.
2. Depress pressure release button (if present) to relieve pressure in filter housing.
3. Unscrew housing using spanner wrench.

   NOTE: When opening filter housing to change cartridge, it is common for O-ring/Gasket to lift out of housing and stick to cap.
4. Remove used cartridge and discard. Rinse out housing and fill about 1/3 full with water. Add about 2 to 3 tablespoons of bleach and scrub thoroughly with brush or sponge. Rinse thoroughly.
5. Remove O-ring/Gasket from sump and wipe groove and O-ring/Gasket clean. Lubricate O-ring/Gasket with a coating of clean petroleum jelly (Vaseline). Place O-ring/Gasket back in place and press O-ring down into the groove with two fingers (or place gasket on rim of sump).

   NOTE: This step is important to ensure proper filter seal. Make sure the O-ring is seated level in the groove (or gasket is on rim of sump).

   CAUTION: If O-ring/Gasket appears damaged or crimped it should be replaced at this time. See your local dealer for replacement parts.
6. Insert a new cartridge into the sump making sure that it slips down over the sump standpipe.
7. Screw the sump onto the cap and hand tighten. DO NOT OVER-TIGHTEN. Make sure cartridge slips over the cap standpipe.
8. Turn on the water supply slowly to allow housing to fill with water. When using a Valve-In-Head, rotate handle slowly to the ON (Filter) position.
9. Depress the pressure release button (if present) to release trapped air from filter.
10. Check for leaks before leaving installation.

WARNING: Do not use with water that is microbiologically unsafe or of unknown quality without adequate disinfection before or after the unit.

NOTE: An activated carbon cartridge (Taste/Odor) may contain a small amount of carbon fines (very fine black powder) and a new cartridge, after installation, should be flushed with sufficient water to remove the fines before using the water.

Each time you use water from your filtered water tap for drinking or cooking purposes, it is recommended that you run (flush) the tap at least 10 seconds prior to using water. This is particularly important if the water tap is not used daily.

NOTE: Certain types of harmless bacteria will attack cellulose material. Cartridges containing cellulose may seem to disintegrate, produce a "sewer" or "rotten-egg" odor, or form a black precipitate due to the bacteria. If you notice any of the above problems while using the cellulose media cartridges, switch to a synthetic media cartridge or consult the manufacturer.

NOTE: This replacement cartridge has a limited service life. Changes in taste, color and flow of the water being filtered are signals that replacement of the cartridge is or soon may be necessary.

CAUTION: Filter must be protected against freezing. Failure to do so may result in cracking of the filter and water leakage.

CAUTION: All filtration systems contain other parts that have a limited service life. Exhaustion of the service life of those parts often cannot be easily detected. Commonly, it is only after leakage has been observed or water damage has occurred that one is made aware that the service life has been exhausted.

IMPORTANT NOTE: To prevent costly repairs or possible water damage we strongly recommend that the bowl or sump of all plastic housings be replaced periodically: every five years for clear sump, and every ten years for opaque sumps. If your sump has been in use for more than the recommended period, it should be replaced immediately. Be sure to date any new or replacement sump with indelible ink for future reference and indicate the next recommended replacement date.

Should you have an Ametek filter housing and have a question concerning its age, please contact Ametek at 1-800-645-5426.

AMETEK
PLYMOUTH PRODUCTS DIVISION
502 INDIANA AVENUE - P.O. BOX 1047
SHEBOYGAN, WISCONSIN 53082-1047, U.S.A.

142555 10/93

MASTER METER

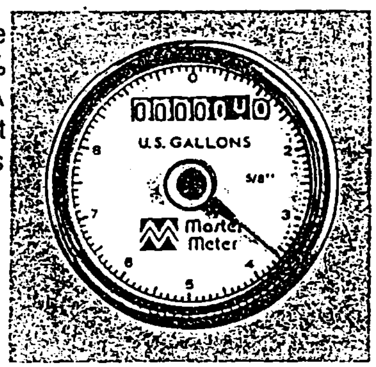
Master Meter Magnetic Multi-Jet Water Meters 5/8"- 1"

The Master Meter Magnetic Multi-Jet dry dial meter is the most efficient meter you can find. The new MM series offers the time proven Multi-Jet concept combined with the center- sweephand sealed register that is preferred by most water utilities.

The Multi-Jet design offers superior accuracy over a wide range of flows, with low head loss even at high flows. The magnetic-drive vacuum-sealed register protects the register assembly from rust, sand and other water impurities. The center sweephand register has large numerals for easy reading and testing.

MM FEATURES

BRONZE METER HOUSING•Available with or without frost protection • 81% Copper content exceeds AWWA • Wrench pads for ease in installment • Complete in line serviceability • Brass case and lid • Sealed adjusting port.



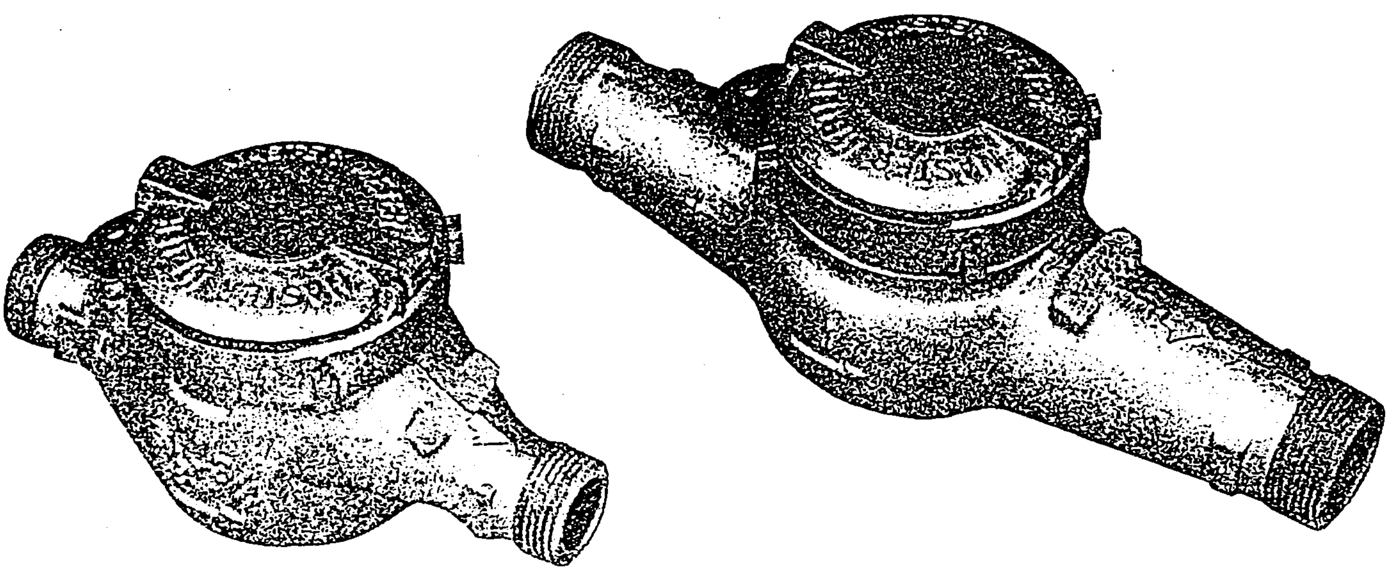
MOLDED CHAMBER • Port holes molded - not machined • Corrosion resistant • Large basket strainer • extremely accurate - all flows • Sapphire rotor bearing

SEALED REGISTER • Vacuum-sealed stainless steel register • Magnetic Drive • Center sweephand • Leak indicator • Large numeral wheels • Easy to read • Tempered glass lens • Easily adapted to metric • Damage resistant brass sealing ring

BENEFITS

• Most accurate of all meter designs • Eliminates discoloring of dial face • Easy and inexpensive to maintain • Low Head Loss • Can be serviced in line • Long life for all parts • Corrosion resistant • Eliminates fogging

MASTER METER© WATER METERS MEET OR EXCEED AWWA C-708



MASTER METER

816 McKESSON DRIVE
LONGVIEW, TEXAS 75604
214-297-0635
1-800-527-8466 US

Size		5/8" x 1/2"	5/8" x 3/4"	3/4"	1"
Flow rating (at 13 psi Loss of Head)	gpm	20	25	30	50
Continuous flow rate	gpm	10	15	20	30
Normal flow range	gpm	1-20	1-20	2-30	3-50
Low flow range	gpm	1/4	1/4	1/2	3/4
Maximum working pressure	psi	150	150	150	150
Maximum working temp.	°F	122°	122°	122°	122°

Size	L	L w/Couplings	H	W.	Weight
5/8" x 1/2"	7 1/2"	12 1/2"	4 3/4"	3 3/4"	4.0 lbs
5/8" x 3/4"	7 1/2"	12 1/2"	4 3/4"	3 3/4"	4.0 lbs
3/4" SL	7 1/2"	12 1/2"	4 3/4"	3 3/4"	4.0 lbs
3/4"	9"	14 1/4"	4 3/4"	3 3/4"	4.25 lbs
1"	10 3/4"	16 1/2"	4 3/4"	4 1/8"	5.5 lbs

THE MASTER METER GUARANTEE

The MM meter by Master Meter is guaranteed to perform to AWWA standards for new meter accuracy and to be free from defects in materials or workmanship for a period of two (2) years from the date of shipment. Additionally, the meters will perform to at least AWWA standards for repaired meter accuracy for the time period or registration limits indicated:

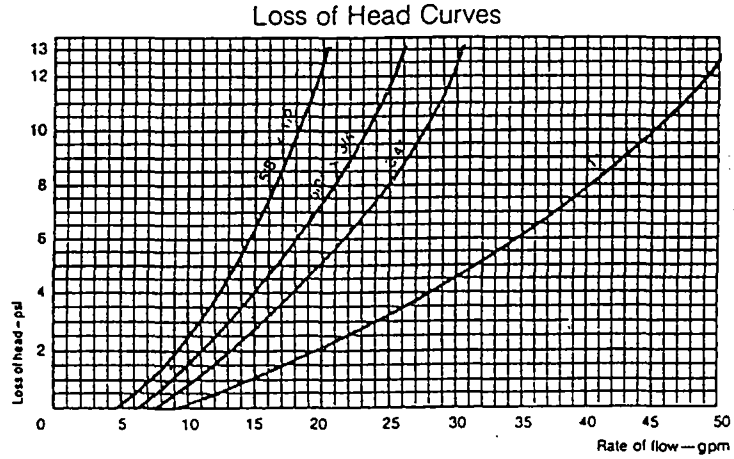
- ⅝" – Fifteen (15) years or 1,500,000 gallons, whichever occurs first;
- ¾" – Fifteen (15) years or 2,000,000 gallons, whichever occurs first;
- 1" – Fifteen (15) years or 3,000,000 gallons, whichever occurs first;
- 1½" – Fifteen (15) years or 5,500,000 gallons, whichever occurs first;
- 2" – Fifteen (15) years or 8,000,000 gallons, whichever occurs first;

The meter body of all sizes is guaranteed against manufacturing defects for 25 years.

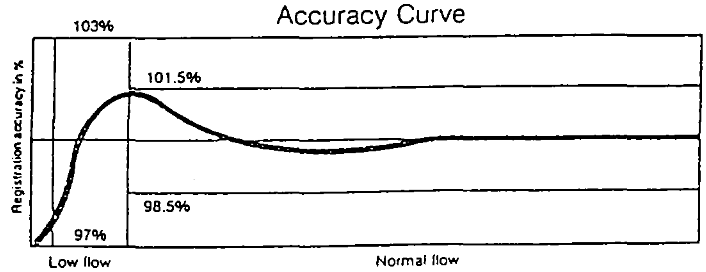
Master Meter's liability under this performance guarantee is expressly limited to repair of the meter upon the customer's returning the meter to the factory or service center designated by a Master Meter representative and paying freight cost to such factory or service center.

This performance guarantee shall not be applicable to meters which have been damaged by willful misconduct, negligence, vandalism, act of God, exposure to adverse service conditions or improper installation.

Loss of Head Curves



Accuracy Curve



Distributed by:

All Master Meters Meet or Exceed AWWA Standard C708

HAYWARD INDUSTRIAL PRODUCTS, INC.

900 FAIRMOUNT AVENUE • P.O. BOX 18 • ELIZABETH, NEW JERSEY 07207 908-351-5400
FAX 908-351-77

BUTTERFLY VALVE
INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS

INSTALLATION

Hayward Butterfly Valves should be installed between two pipe flanges. In dead end service, it is recommended they be installed between one pipe flange and a downstream companion or blind flange.

The "Lug" design can be installed on one pipe flange with a maximum upstream pressure of 75 PSI; flow must be in the direction of the arrow on the body. The use of additional gaskets are not necessary and not recommended.

When installed between two existing flanges, the flanges should be separated to provide clearance on the face to face of valve. This will prevent the valve sealing surfaces from distortion during installation. Pipe flange faces should be clean, free of debris, and old gasket material. Additionally, the flange sealing surfaces of the liner should be lightly lubricated using a non-hydrocarbon base lubricant such as "Non-Fluid Oil" #666.

Hayward Butterfly Valves are designed for use with all pipe flanges up to and including schedule 80. Should the use of pipe flanges greater than schedule 80 (example: schedule 120) occur, the inside of the flange at the valve must be chamfered to a diameter greater than or equal to the inside diameter of schedule 80 pipe. Sharp edges and burrs must be removed.

The Butterfly Valve should be open to approximately 15° when installed. Do not open fully during installation to prevent possible damage to the edge of the disc by the mating flanges.

With actuated valves, follow these procedures for opening of disc to approximately 15°.

ELECTRIC: Apply power to actuator for a short duration to allow disc to partially open (approx. 15°).

PNEUMATIC: *Double Acting:* (Air to Air) with air lines disconnected use manual override to rotate disc to partially open position (approx. 15°).
Spring Return: (Air to Spring) with the air supply connected, and an air regulator installed in the a supply line; slowly adjust the air regulator upward from "O" PSI until just enough air pressure has been applied to the actuator, to partially open the disc (approx. 15°).

Install the valves using well-lubricated studs or bolts with metal back-up washers on both pipe flanges. With a torque wrench, uniformly tighten nut (or bolt) to approximately 15 foot pounds in an alternating sequence, diametrically opposed to the previously tightened nut. Final tightening should be performed in the same sequence following the recommended torque in the following chart.

The maximum allowable displacement is 1/8" off pipe center in any direction. Maximum angular misalignment of 3/32" for 3" and 4" valves, and 1/8" for 6" and 8" valves is allowed.

Normal pipe hanger spacing is recommended. Do not allow valve to support the weight of pipe. When using pneumatic or electric actuators, additional support directly to the actuator is recommended.

RECOMMENDED FLANGE BOLT TORQUE FOR PLASTIC BUTTERFLY VALVES

Size (In.)	Stud Dia. (In.)	Bolt Dia. (In.) Thread	Torque Ft. x Lb. Flat Face Type Flange	Torque Ft. x Lb. Van-Stone Type Flange
3	5/8	5/8 - 11UNC	20-25	10-20
4	5/8	5/8 - 11UNC	20-25	10-20
6	3/4	3/4 - 10UNC	30-40	10-20
8	3/4	3/4 - 10UNC	30-40	20-30

NOTE: On Butterfly Valves of the "Lug" design, bolts are recommended.

OPERATION

When installation is complete, check for proper alignment. Fully open and close the valve by rotating through 360° for 6 revolutions. For actuated valves, fully open and close the valve 6 times.

Flange bolt torques in excess of those recommended will increase valve operating torque.

Maximum operating pressure at ambient temperature when installed between two flanges is 150 PSIG.

MAINTENANCE & DISASSEMBLY OF VALVE

I. *Minimal valve maintenance is required:* the valve is field repairable.

II. *Actuator Assembly:* actuators can be removed without removing valve from line. The line should be depressurized before any actuator is removed.

A. *Handle Assembly:* remove black logo bezel by lifting with thin screwdriver or knife, exposing slotted head screw. Remove screw and flat washer. Lift off handle.

B. *Gear Actuator:* remove four (4) hex nuts which hold actuator to body.

C. *Pneumatic/Electric Actuator:* is removed by unscrewing four (4) socket head cap screws and hex nuts which hold the bracket to the body.

III. VALVE DISASSEMBLY

1. Remove cap plug from bottom of valve body (use a ½" drive rachet). Remove o-ring.
2. Remove shaft by pushing from top, out through bottom of valve body.
3. Remove upper elastomeric moisture seal.
4. Remove upper bearing (use the shaft to twist out).
5. Remove lower bearing (use the shaft to twist out.)
6. To remove seal retainers, place shaft through one seal retainer and approximately ¾ through the disc. Rotate disc approximately 30°, push shaft through disc against opposite seal retainer. Corners of shaft will push against flats of seal retainer. Remove shaft, and insert from opposite side of disc. Rotate disc approx. 30° and push out remaining seal retainer.
7. Slide disc out of liner.
8. Remove liner by peeling interlock section from body and folding liner into a heart shape. If the valve is of the "Lug" design, the liner is not removable.
9. Inspect all parts for wear and replace as necessary.
10. To reassemble: lightly lubricate all moving parts and seals (using lubricants suggested on Page 1) and reverse above procedure.

IV. "LUG" MOUNTING

Valves equipped for lug mounting have specially designed stainless steel threaded inserts affixed to the body to allow installation without the use of a downstream flange. Valves used in this type of application have been derated for pressure applications, to a maximum of 75 PSI. The valves can also be used with downstream flanges, in which case, full-rated pressure of 150 PSI is applicable. The advantage to the Lug design is that it allows installation of the valve to be such, that to change flange connections of either side of the valve, the valve does not have to be removed from the piping system.

Installation, Operation and Maintenance Instructions for Snap-tite/GreenTop® Valves

Installation

Wiring

All wiring must comply with the local, state and national electrical codes which are in effect at the time of installation. Valves for watertight and/or hazardous location service must be installed with fittings which have the appropriate approvals. Standard housings are designed for use with 1/2" conduit connections. All GreenTop enclosures may be rotated 360° to facilitate installation. After the electrical connection has been made, tighten the top retaining nut to secure the housing.

Piping

Valves must be installed in accordance with the lettering or arrows which indicate flow direction. Extreme caution should be exercised when applying pipe compound or using Teflon® thread tape. Either should be applied to the male threads only and care must be taken to be certain that excesses of these materials do not enter the internal portions of the valve.

When tightening the valve in place, do not use the core tube or solenoid enclosure as a means of doing so. Wrenches should be applied only to the parts of the valve designated for that purpose.

It is recommended that an appropriate strainer be installed before the valve to filter contaminates.

Valve Positioning

For optimum performance the upright and vertical position is recommended.

Operation

GreenTop valves are tested prior to shipment to ensure proper operation when installed and should provide outstanding service life.

Should a valve fail to operate properly and it is necessary to trouble shoot the installation refer to the replacement and inspection instructions prior to valve disassembly.

Trouble Shooting

1. **Valve Leakage:** Confirm compatibility of materials of construction with the conditions of service. Disassemble the valve and inspect the seat and all parts for damage or wear. Replace all worn or damaged parts.
2. **Coil Burn Out:** Check voltage supply as compared to the valve rating. Also, check the actual pressure against the rated valve pressure.
3. **Improper Closing or Opening:** Check for proper voltage. Disassemble valve and inspect for worn or damaged parts. Replace as needed. Inspect and clean all internal parts including all orifices.
4. **Solenoid not Operating:** If the customary click is not heard when the solenoid is energized, inspect the electrical circuit. Check fuses, lead wires, connections, grounds and voltage.

Temperature of the Solenoid

Normal operation of a solenoid valve over a period of time will generate sufficient heat to cause the enclosure to become hot to the touch. This condition, which will vary depending upon the parameters of the application, is not cause for alarm. However if you observe smoke, discoloration of the housing or coil, or detect the odor of burning insulation the cause of this excessive heat build-up must be determined.

Maintenance

Inspection/Replacement Oil Solenoid Coil General Purpose Housings

1. Turn off electrical supply.
2. Disconnect coil leads.
3. Remove the retaining nut located above the housing.
4. Remove the top of the housing and split washer.
5. Slip coil off the core tube by moving it away from the base of the core tube.
6. Slide the solenoid base plate off the core tube.
7. To reassemble, reverse the order of the above procedures.

Weather Proof and Hazardous Location Housings

1. Turn off electrical supply.
2. Disconnect coil leads.
3. Unscrew the retainer nut assembly at the top of the housing. (Remove the washer and "O" ring, weathertight only).
4. Unscrew the top of the enclosure.
5. Lift off the top plate, yoke, coil and lower housing in that order.
6. Reverse the order of these steps for reassembly.

*Caution: When reassembling weathertight or hazardous location enclosures, all surfaces must be carefully cleaned to ensure that the intended sealing surfaces are achieved.

Inspection/Disassembly of the Valve

1. Relieve the pressure within the system.
2. Cycle the valve once to discharge any pressure which might have built up within the valve.
3. Be sure that the down stream pressure has been secured.
4. Turn off electrical supply.
5. Disconnect conduit and lead wires, if necessary.
6. Remove the entire solenoid enclosure from the valve (see Inspection/Replacement Of Solenoid Coil Instructions).
7. Unscrew core tube from the body of the valve.
8. Carefully, remove the core from the core tube. Do not lose any springs during this process.
9. If the valve body has any screws or bolts, loosen all of them before removing any. Exercise caution during their removal, there are internal springs in many styles.
10. Inspect all parts for wear, damage and dirt. Replace all worn or damaged parts. Clean all internal parts including orifices. Do not use abrasives to remove dirt.
11. Thoroughly, inspect seats for wear or damage. Replace as needed.
12. To reassemble reverse the order of the above procedures. When replacing body bolts or screws these should be hand tightened first.

INSTALLATION, OPERATION AND MAINTENANCE
HAYWARD ELECTRIC ACTUATORS
ALL MODELS

WITH THE HAYWARD PRE-MOUNTED AND FACTORY TESTED, ELECTRIC ACTUATOR, MOUNTING KIT AND VALVE ASSEMBLY, THE FIRST REQUIREMENT FOR PROPER INSTALLATION IS TO:

1.DISCONNECT POWER SUPPLY !

2.REMOVE THE ACTUATOR COVER.

INSIDE THE COVER YOU WILL FIND ALL OF THE APPROPRIATE WIRING DIAGRAM INFORMATION TO ALLOW YOU TO PROPERLY INSTALL EACH ACTUATOR. ON THOSE MODELS REQUIRING MORE THAN FOUR (4) COVER SCREWS, THE ADDITIONAL SCREWS ARE PACKAGED IN A POLYBAG INSIDE THE ACTUATOR.

THE INSTALLATION WIRING DOCUMENTATION HAS BEEN PLACED INSIDE THE ACTUATOR IN THE FORM OF A LABEL AFFIXED TO THE INSIDE OF THE TOP COVER OR PRINTED ON A FOLDED INSTALLATION, OPERATION SHEET.

SHOULD YOU HAVE PURCHASED AN ACTUATOR WITH MULTIPLE OPTIONS, WE MAY HAVE PLACED THE ADDITIONAL INSTALLATION OPERATION DOCUMENTATION INTO A HEAT SEALED POLYBAG PLACED WITHIN THE SHIPPING CARTON. LOOK CAREFULLY INSIDE THE CARTON TO BE SURE THAT YOU DO NOT ACCIDENTLY DISCARD THESE IMPORTANT DOCUMENTS.

COMPLIANCE OF LOCAL BUILDING/ELECTRICAL CODES:

THE ELECTRICAL CONNECTIONS TO THE ACTUATOR MUST BE PROPERLY CONNECTED CONSISTANT WITH THE INSTALLATION SCHEMATIC(S) TO THE TERMINAL STRIP(S) AFFIXED WITHIN THE ACTUATOR, OR IN CASES WHERE MULTIPLE ADDITIONAL LIMIT SWITCHES HAVE BEEN INSTALLED, TO THE WIRE LEADS WITH PROPERLY SIZED WIRE CONNECTORS AS REQUIRED BY CODE.

ALL HAYWARD ELECTRIC ACTUATORS CARRY A TWO (2) YEAR WARRANTY FOR MATERIAL DEFECTS AND WORKMANSHIP.

ACTUATOR COUPLING

DO NOT USE COUPLINGS OTHER THAN THAT SUPPLIED WITH THIS VALVE/ACTUATOR COMBINATION FOR INTERFACE BETWEEN THE ACTUATOR AND THE VALVE.

IMPORTANT TORQUE NOTICE

WHEN ATTACHING HAYWARD PLASTIC MOUNTING BRACKETS TO HAYWARD VALVES, THE FOLLOWING TORQUE SPECIFICATIONS FOR TIGHTENING OF ACTUATOR MOUNTING BRACKET BOLTS TO VALVES SHOULD BE FOLLOWED:

BALL VALVES:

BOLT SIZE	VALVE SIZE	TORQUE SPECIFICATION
1/4" THREAD	1/4" THRU 2"	25 TO 30 INCH POUNDS
3/8" THREAD	2 1/2" THRU 6"	70 TO 90 INCH POUNDS

BUTTERFLY VALVES:

3/8" THREAD	1/2" THRU 12"	100 TO 140 INCH POUNDS

HAYWARD CONTROLS
INSTRUCTION MANUAL
for
EVR-SERIES (Reversing) ELECTRIC ACTUATORS

⚠ This instruction manual contains important information regarding the installation and operation of the EVR-Series Electric Actuators. Please read these instructions carefully and save them for future reference.

Description

Hayward Controls's EVR-Series Electric Actuators are designed to provide reliable and efficient operation of 1/4 turn valves. The supported torque range for actuation is between 100 and 600 inch pounds. EVR-Series actuators are available in AC models with a 25% duty cycle and DC models with a 100% duty cycle. Note: If the actuator will be mounted on a butterfly valve, ensure that the actuator is equipped with a Motor Brake. This factory installed option is shown by a "K" in the model number on the actuator nameplate.

Parts List

1 - Limit Switch
2 - Cams
3 - Override/ Cam Shaft
4 - O-Ring

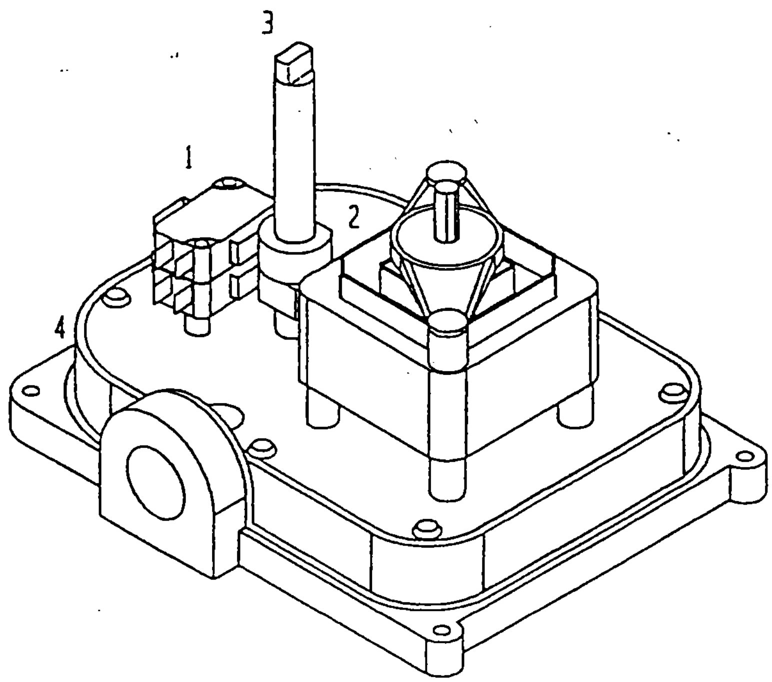


Figure 1 *Parts Identification*

Installation

CAUTION: Dangerous voltages are present inside the actuator unless the power supply to the actuator has been shut off or disconnected. Use extreme caution whenever working on the actuator with the cover removed.

Temperature Limits

Low ambient temperatures: The minimum recommended ambient temperature without the optional heater and thermostat is approximately 30°F (although it varies with the frequency of use). With the optional heater and thermostat installed, the recommended minimum ambient temperature is -40°F.

High ambient temperatures: The maximum recommended ambient temperature is 160°F.

High media temperatures: For media temperatures up to 200°F, additional precautions are not typically required. For media temperatures between 200°F and 300°F, a shielding plate about one inch larger than the actuator in each dimension should be placed between the actuator and the mounting bracket. In addition, the actuator should be mounted at the 3 o'clock or 9 o'clock position relative to the pipe. For media temperatures above 300°F, a valve with an extended shaft mounting arrangement should be used.

Mounting the Actuator

First verify that the output torque of the actuator is appropriate for the torque requirements of the valve and that e actuator duty cycle is appropriate for the intended application.

NOTE: A 25% duty cycle means that for every operating cycle that the actuator is ON (to open or close the valve), the actuator must be OFF for a time equal to three operating cycles. For example, if the operating cycle time is 5 seconds, for every operating cycle that the actuator is ON, it must be OFF for 15 seconds. **Exceeding the actuator's duty cycle may cause the thermal overload switch to temporarily shut off power to the motor.**

Actuator Drive Output Requirements: Hayward Controls's EVR-Series actuators have a male drive output with 0.375" flats. Two industry standard bolt hole circle configurations are provided (see Figure 2).

Bracket requirements: **It is mandatory that the actuator be firmly secured to a sturdy mounting bracket.** A minimum of four bolts must be used to secure the actuator to the bracket. There can be no flexibility in the bracket, and backlash ("play") in the coupling should be minimized. In addition, the actuator output shaft must be in line (centered) with the valve shaft. This avoids side-loading the shafts.

Manual Override

To operate the actuator manually, remove the position indicator. Then push the override shaft down fully (approximately 1/4"), and use a 5/16" wrench on the flats of the shaft to rotate the actuator. Pushing the override shaft down disengages the gear train and directly rotates the output shaft. Note: It is also possible

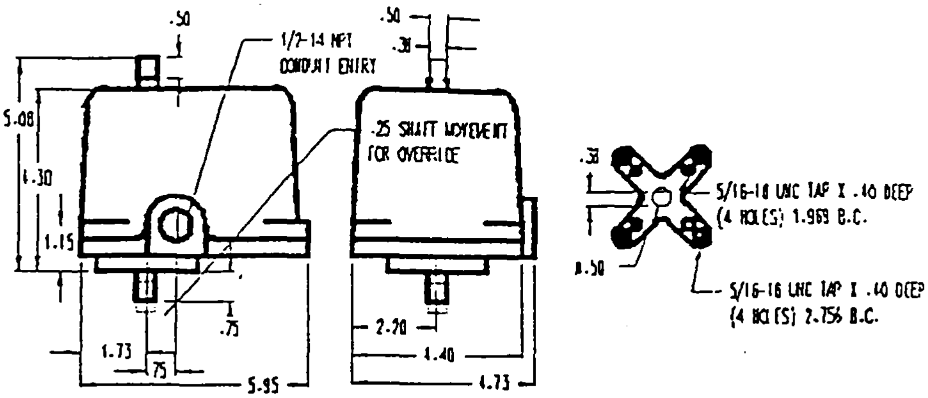


Figure 2 *Dimensions*

to turn the override shaft without pushing it down. The gear train is then still engaged and the override shaft must work through the gear train to rotate the actuator.

Wiring

Note: Be sure to follow local wiring codes.

The identification label on each actuator specifies the voltage and current requirements for the actuator. Figure 3 shows the standard power and control wiring connections for AC and DC actuators. To operate the EVR actuator, the user supplies power to the actuator's motor through two limit switches. The limit switches control the actuator's mechanical travel limits and are factory set at 90 degrees.

VAC

To drive the actuator counterclockwise (CCW), apply power to terminals 1 and 3. To drive the actuator clockwise (CW), apply power to terminals 1 and 4. The actuator can be driven fully open (CCW) or closed (CW) by maintaining power to the motor until the actuator trips the internal limit switches. Power can also be disconnected at any point during the travel to position the actuator.

VDC

DC voltage actuators require a reversing of the power polarity. To drive the actuator CW, apply power so that terminal 1 is negative and terminal 4 is positive. To drive the actuator CCW, apply power so that terminal 1 is positive and terminal 3 is negative.

Adjustment of the Limit Switch

The limit switch is actuated by the cam on the output shaft and sets the 0°, 90°, 180° and 270° positions where the actuator will stop at the end of each cycle. If adjustment of the open or closed position is required, proceed as follows:

A. Remove the Actuator Cover

Remove the actuator cover by removing the screws securing the cover to the base.

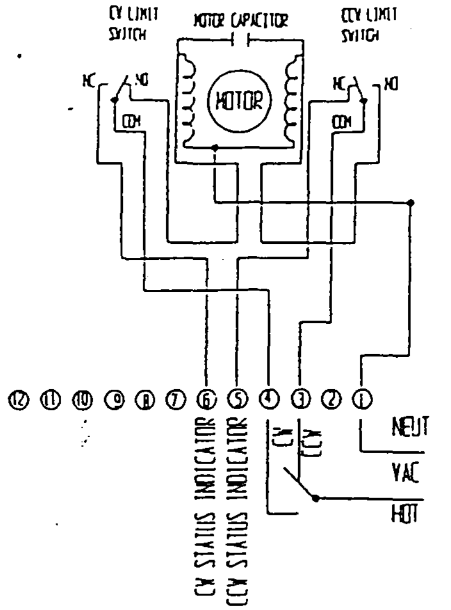


Figure 3A *Wiring Diagram VAC*

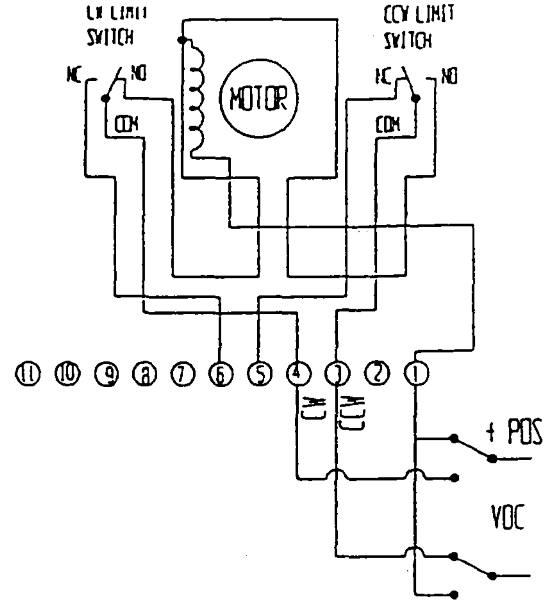


Figure 3B *Wiring Diagram VDC*

B. Adjust the Cam

1. Operate the actuator and observe where it stops in the open and closed positions. Note whether the actuator is stopping **short** of the desired open and closed positions or traveling **beyond** the desired open and closed position.

2. Continue to cycle the actuator from closed to open positions until the cam stops at a position where you can reach the cam set screw with the hex wrench.

3. Remove power from the actuator.

4. Using the 1/16 inch hex wrench, loosen the set screw in the cam.

5. If the actuator is stopping short of the desired stopping positions, rotate the cam slightly toward the limit switch arm (Counterclockwise). Note: Cam adjustments affect both the open and closed stopping positions equally.

6. If the actuator is traveling beyond the desired stopping positions, rotate the cam slightly away from the limit switch arm (Clockwise). Note: Cam adjustments affect both the open and closed stopping positions equally.

7. Re-tighten the set screw in the cam (be careful not to over-tighten the screw).

C. Replace the Actuator Cover

NOTE: When reinstalling the cover, follow the normal practice of tightening the cover screws in a cross pattern to insure that the cover is pulled down flat without over-stressing a corner.

Options

Additional Limit Switches:	Two field-installable additional limit switches are available.
Heater and Thermostat:	A field-installable heater and thermostat is available for low temperature or high humidity applications.
Timer Board:	An optional timer board is available but must be factory installed in the actuator.

Hayward Industrial Products Incorporated
900 Fairmount Avenue, Elizabeth, NJ 07207
Phone: (908)351-5400, Fax: (908)351-7706
A Hayward Industries Company

HAYWARD INDUSTRIAL PRODUCTS
INSTALLATION OPERATION & MAINTENANCE OF TRUE UNION BALL VALVES

SOCKET CONNECTION:

Socket end connections are manufactured to ASTM D2467-87A. Solvent cementing of socket end connections to pipe should be performed per ASTM specifications D2855-87. Cut pipe square. Chamfer and deburr pipe. Surfaces must be cleaned and free of dirt, moisture, oil and other foreign material. Remove assembly nuts and end connectors from valve body. Slide assembly nuts, with threads facing valve, onto pipe to which the end connector is to be cemented. Apply primer to inside socket surface of end connector. Never allow primer or cement to contact valve ball or end connector o-ring sealing surfaces, as leaking may result. Use a scrubbing motion. Repeat applications may be necessary to soften the surface of the socket. Next, liberally apply primer to the male end of the pipe to the length of the socket depth. Again apply to the socket, without delay apply cement to the pipe while the surface is still wet with primer. Next apply cement lightly, but uniformly to the inside of the socket. Apply a second coat of cement to the pipe, and assemble the end connector to the pipe, rotating the end connector 1/4 turn in one direction as it is slipped to full depth on to the pipe. The end connector should be held in position for approx. 30 seconds to allow the connection to "set". After assembly wipe off excess cement. Full set time is a minimum of 30 minutes at 60 to 100 F. Full cure time should be based on the chart below.

JOINT CURE SCHEDULE:

The cure schedules are suggested as guides. They are based on laboratory test data, and should not be taken to be the recommendations of all cement manufacturers. Individual manufacturer's recommendations for their particular cement should be followed.

Temperature Range During Cure Period(B) °F(°C)	Test Pressures for Pipe Sizes 1/2 to 1-1/4 In.		Test Pressures for Pipe Sizes 1-1/2 to 3 In.		Test Pressures for Pipe Sizes 4 to 5 In.		Test Pressures for Pipe Sizes 6 to 8 In.	
	Up to 180 PSI (1240 kPa)	Above 180 to 370 PSI (1240 to 2550 kPa)	Up to 180 PSI (1240 kPa)	Above 180 to 315 PSI 1240) to 2170 kPa)	Up to 180 PSI (1240 kPa)	Above 180 to 315 PSI (1240 to 2170 kPa)	Up to 180 PSI (1240 kPa)	Above 180 to 315 PSI (1240 to 2170 kPa)
60 to 100 (15 to 40)	1 h	6 h	2 h	12 h	6 h	18 h	8 h	24 h
40 to 60 (5 to 15)	2 h	12 h	4 h	24 h	12 h	36 h	16 h	48 h
20 to 40 (-7 to 5)	6 h	36 h	12 h	72 h	36 h A	4 days A	3 days A	9 days A
10 to 20) (-15 to 7)	8 h	48 h	16 h	96 h	72 h A	8 days A	4 days A	12 days A
Colder than 10 (-15)	Extreme care should be exercised on all joints made where pipe, fittings or cement is below 10°F.							

A: It is important to note that at temperatures colder than 20°F on sizes that exceed 3 in., test results indicate that many variables exist in the actual cure rate of the joint. The data expressed in these categories represent only estimated averages. In some cases, cure will be achieved in less time, but isolated test results indicate that even longer periods of cure may be required.
B: These cure schedules are based on laboratory test data obtained on Net Fit Joints (NET FIT=in a dry fit the pipe bottoms snugly in the fitting socket without meeting interference).

THREADED CONNECTION:

Threaded end connections are manufactured to ASTM specifications D2464-88. F437-88 and ANSI B2.1. Wrap threads of pipe with Teflon tape of 3 to 3-1/2 mil thickness. The tape should be wrapped in a clockwise direction starting at the first or second full thread. Overlap each wrap by, 1/2 the width of the tape. The wrap should be applied with sufficient tension to allow the threads of a single wrapped area to show through without cutting the tape. The wrap should continue for the full effective length of the thread. Pipe sizes 2" and greater will not benefit with more than a second wrap, due to the greater thread depth. To provide a leak proof joint, the pipe should be threaded into the end connection "hand tight". Using a strap wrench only. (Never use a stillson type wrench) tighten the joint an additional 1/2 to 1-1/2 turns past hand tight. Tightening beyond this point may induce excessive stress that could cause failure.

FLANGED CONNECTION:

Flange bolts should be tight enough to slightly compress the gasket and make a good seal, without distorting or putting excessive stress on the flanges. Suitable washers should be used between the bolt head and flange and the nut and flange. Bolts should be tightened in alternating sequence.

RECOMMENDED FLANGE BOLT TORQUE

FLANGE SIZE	BOLT DIA.	TORQUE FT. LBS.	FLANGE SIZE	BOLT DIA.	TORQUE FT. LBS.
1/2	1/2	10-15	2	5/8	15-25
3/4	1/2	10-15	2-1/2	5/8	20-25
1	1/2	10-15	3	5/8	20-25
1-1/4	1/2	10-15	4	5/8	20-25
1-1/2	1/2	10-15	6	3/4	30-40

NOTE: USE WELL LUBRICATED METAL BOLTS AND NUTS. USE SOFT RUBBER GASKETS.

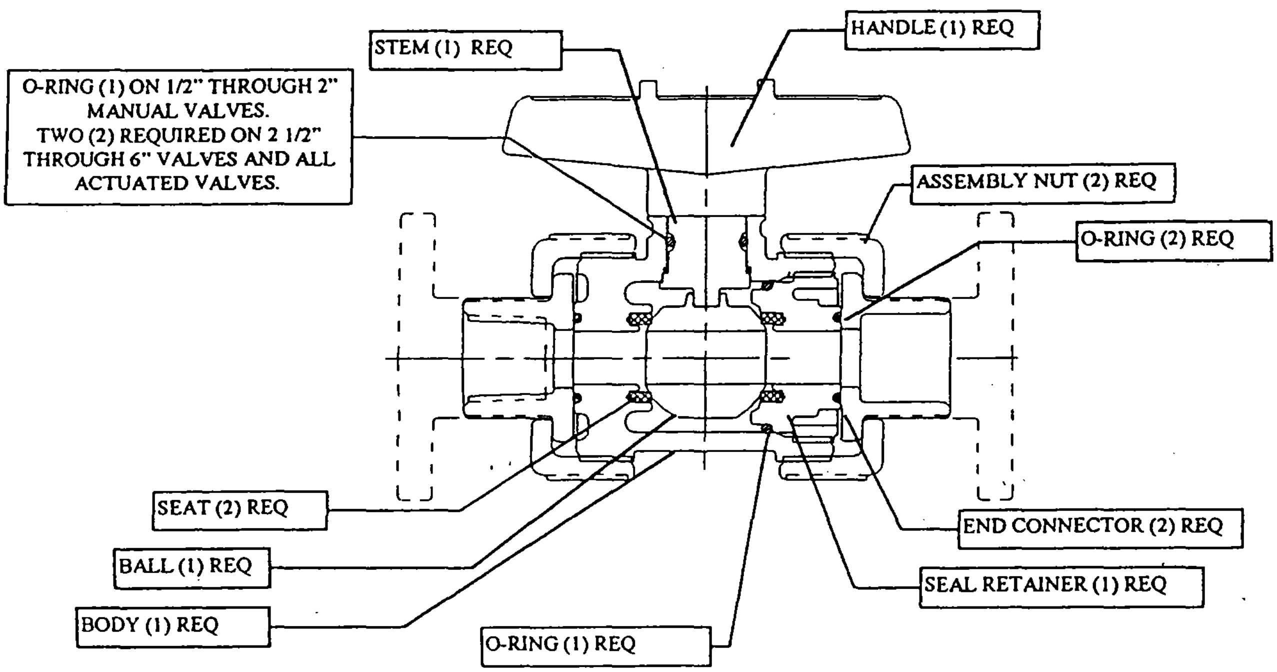
ADJUSTMENT:

EXTREME CAUTION MUST BE TAKEN WHEN WORKING ON THIS VALVE. THE PIPING SYSTEM MUST BE DEPRESSURIZED AND DRAINED. PROPER CARE MUST BE TAKEN. CONSULT M.S.D.S. (MATERIAL SAFETY DATA SHEETS) INFORMATION REGARDING YOUR SPECIFIC APPLICATION.

Remove the assembly nut and end connector from the "adjust" end of the body, or the complete valve body from the piping system. The front face of the seal retainer indicates which direction of rotation tightens or loosens the seal retainer, with the word "tighten" and a directional arrow, and the word "loosen" and a directional arrow. Direction of rotation may vary depending on date of manufacture. The Assembly nut should be installed on the valve "hand tight". Using a strap wrench only the joint may be tightened 1/2 to 3/4 of a turn past hand tight.

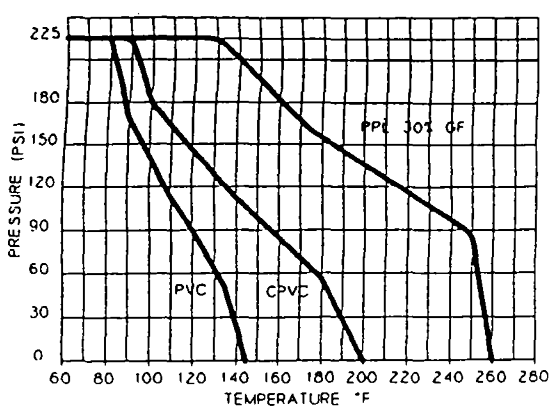
REPAIR:

Follow the adjustment sequence and information above, but rotating the seal retainer completely in the "loosen" direction and remove it from valve body. The o-rings and seals are now accessible for replacement using a "seal" repair kit. Carefully remove the o-rings from their respective locations taking care not to scratch their sealing surfaces. Use a non-petroleum base lubricant to lubricate the o-rings, and re-assemble the valve. See table below.



OPERATING PRESSURE
TEMPERATURE

TRUE UNION, TRUE CHECK, & SINGLE ENTRY ONLY



Recommended valve stem torque to rotate the ball 360° when valve is reassembled.

VALVE SIZE	TORQUE IN•LB
1/2"	30
3/4"	40
1"	50
1 1/4"	60
1 1/2"	60
2"	80
3" & 2 1/2"	140
4" & 6"	170

NEPCCO

RECOMMENDED MONTHLY MAINTENANCE CHECK LIST - PUMPS

DATE								
ELECTRIC SUBMERSIBLE								
1. Check operating amps of pump motor								
2. Inspect probe. Clean if required.								
PNEUMATIC SUBMERSIBLE								
1. Check effluent from pump for excessive air discharge. If so, adjust timer as required.								
2. Inspect tubing.								
3. Check particulate filter.								
4. Check membrane dryer for debris.								
TRANSFER PUMPS								
1. Check motor coupling. Tighten if necessary.								
2. Check operating amps of transfer pump motor.								
3. Inspect shaft seal for leakage (if applicable).								
MAINTENANCE COMPLETED BY:								

DATE	COMMENTS

FAILURE TO PERFORM RECOMMENDED MONTHLY MAINTENANCE MAY RESULT IN PREMATURE EQUIPMENT FAILURE AND VOID APPLICABLE WARRANTIES.

NEPCCO

RECOMMENDED MONTHLY MAINTENANCE CHECK LIST - OIL/WATER SEPARATOR

DATE								
1. Check sludge level accumulation in the influent and separation chambers.								
2. Check trough and oil discharge opening for debris accumulation and blockage.								
3. Inspect and clean coalescing tubes as required.								
4. Check Hi Hi probe in product tank, clean as required.								
5. Check level in product tank.								
MAINTENANCE COMPLETED BY:								

DATE	COMMENTS

FAILURE TO PERFORM RECOMMENDED MONTHLY MAINTENANCE MAY RESULT IN PREMATURE EQUIPMENT FAILURE AND VOID APPLICABLE WARRANTIES.

NEPCCO

RECOMMENDED MONTHLY MAINTENANCE CHECK LIST - VEP SYSTEM

DATE								
GENERAL								
1. Check operating amps of vacuum pump motor.								
2. Inspect dilution air filter, clean if required.								
3. Record vacuum gauge reading for reference.								
4. Ensure seal water source operational. (5 gpm minimum)								
5. Inspect sediment filter in seal water line, replace cartridge if necessary.								
6. Inspect Multilevel probe(s) in seal water/separator tank(s).								
MAINTENANCE COMPLETED BY:								

DATE	COMMENTS

FAILURE TO PERFORM RECOMMENDED MONTHLY MAINTENANCE MAY RESULT IN PREMATURE EQUIPMENT FAILURE AND VOID APPLICABLE WARRANTIES.

NEPCCO

RECOMMENDED MONTHLY MAINTENANCE CHECK LIST - SYSTEM

	DATE							
1. Collect influent and effluent samples.								
2. Insure no leaks in system piping.								
3. Inspect system instrumentation for damage.								
4. Check site condition (pick up trash, etc.).								
5. Inspect fence/building for damage.								
MAINTENANCE COMPLETED BY:								

DATE	COMMENTS

FAILURE TO PERFORM RECOMMENDED MONTHLY MAINTENANCE MAY RESULT IN PREMATURE EQUIPMENT FAILURE AND VOID APPLICABLE WARRANTIES.

TROUBLESHOOTING GUIDE

NEPCCO strives to manufacture low maintenance, trouble free remediation systems, however an occasional problem may arise. The following guideline has been developed to aid the technician in troubleshooting the system in the field.

Should you require further assistance, please call NEPCCO's Field Service number @ 1-800-277-3279. In order to provide fast efficient technical assistance, **PLEASE REFER TO NEPCCO'S 6 DIGIT EASYPURGE™ SYSTEM NUMBER IN ALL CORRESPONDENCE**. This ,mber is easily located on the system manual cover, on all engineering drawings, inside all control panels and is permanently stamped on the skid deck near the control panel stanchion. Not providing the system number may cause a delay in obtaining technical assistance.

CAUTION

SOME TROUBLESHOOTING PROCEDURES MAY INVOLVE MEASURING AC VOLTAGES. AC VOLTAGE MEASUREMENTS, ELECTRICAL MAINTENANCE AND REPAIRS SHOULD BE PERFORMED BY QUALIFIED SERVICE PERSONNEL

SYMPTOM	POSSIBLE CAUSES	CORRECTIVE ACTION
RECOVERY WELL PUMP WILL NOT OPERATE	Probe placed incorrectly in well	Verify that the probe is placed at the correct depth in the well
	Bad pump motor	If pump does not operate in the manual position and the control panel delivers 240 VAC to the pump motor, replace the pump motor
	Internal or external thermal overloads	Reset thermal overload. Check the recovery well pump for proper depth Check pump inlet for any debris blockage Ensure that the pump shaft rotates freely Ensure that excessive cycling does not occur
	Bad probe	Perform continuity test as per the HydroPurge™ or PetroPurge™ section of the manual
	Bad logic card	If the pump runs when the control panel switch is in the manual position and not in the "AUTO" position, and all of the above checks have been performed to verify that the probe is good, swap or replace the logic card. Ensure the logic card is plugged in correctly.
	Control panel switches in "OFF" position	Place switches to the "AUTO" position
	Circuit breaker tripped or in "OFF" position	Reset breaker or place in the "ON" position
	Incorrect wiring	Verify that pump motor is wired correctly as per system manual
	Control panel power supply	Verify that the 5VDC power supply is operational "RED LED ON"

SYMPTOM	POSSIBLE CAUSES	CORRECTIVE ACTION
NO POWER TO SYSTEM	Main service disconnect tripped	Reset breaker
	System circuit breaker tripped or in the "OFF" position	Reset breaker
BLOWER DOES NOT DELIVER CORRECT CFM	Motor running backwards	Verify that blower motor is wired correctly
	Blower blade binding	With all power off determine cause of binding
	Damper not adjusted correctly	Loosen set screw and adjust damper as necessary
	Debris blocking inlet screen	Remove any debris that may have collected at inlet screen
BLOWER WILL NOT RUN	Starter switch in "OFF" position	Place switch to "ON" or "START"
	Blower circuit breaker tripped or in "OFF" position if so equipped	Reset breaker or place to "ON" position
	Blower motor starter thermal overload tripped	Reset thermal overload
TRANSFER PUMP WILL NOT OPERATE	System failsafe, if so equipped Bad multi-level probe	Corrective action for recovery well pump also applies to transfer pumps with the exception that transfer pumps operate with a multi-level probe. Please refer to the Pump & Controller section of the system manual for multi-level probe test procedures.

SYMPTOM	POSSIBLE CAUSES	CORRECTIVE ACTION
RECOVERY WELL PUMP CYCLES INCORRECTLY	Probe connected incorrectly Probe placed incorrectly Logic card inoperative	Refer to manual and veiify probe connections Refer to manual and verify correct probe placement Replace logic card
TRANSFER PUMP CYCLES INCORRECTLY	Multi-level probe operating incorrectly	The above procedure applies to transfer pumps with the exception that transfer pumps operate with a multi-level probe
CONTROL PANEL INOPERATIVE	No AC power Power supply inoperative	Verify AC power at TB-1 Verify that 5VDC power supply is operational, "RED LED ON". Check fuses and replace as necessary
FAILSAFE PANEL WILL NOT RESET	Failsafe condition not corrected	All failsafe sensors are wired normally open and the failed condition is closed. Verify that the failsafe condition has been corrected
BLOWER FAILSAFE WILL NOT RESET	Air line to pressure switch blocked Blower not running Blower damper closed	Clear lines or tubing of water or debris from sump to pressure switch. Verify that the blower is running Open and adjust blower damper
LEVEL SENSORS WILL NOT WORK	Level sensor floats inoperative	Ensure that the floats operate freely Ensure that all Hi-Hi level sensors are in the DOWN N. O. position and all Lo-Lo sensors are in the UP N.O. position

SYMPTOM	POSSIBLE CAUSES	CORRECTIVE ACTION
AIR COMPRESSOR INOPERATIVE	No AC power	Verify AC power at motor starter Verify AC power at motor weather head
	Low oil level	Check oil level and fill

NOTES

OPERATIONS AND MAINTENANCE MANUAL
MULTIPHASE RECOVERY SYSTEM
FUEL FARM 216
NAS CORPUS CHRISTI, TEXAS

ATTACHMENT 11

THERMTECH OPERATION AND MAINTENANCE MANUAL

OPERATION & MAINTENANCE MANUAL

VAPOR CHECK

VAC 10

Customer:	**Applied Earth Sciences**
Location:	**Corpus Christi, TX**
PO Number:	**243-05616**
Unit Number:	**9460497**
Ship Date:	**4/97**

THERMTECH, INC. Sales 281-359-7555 FAX: 281-359-7550
1-800-659-8271
Service 281-359-7542

VER. 1.11 (10-96)

TABLE OF CONTENTS

I INTRODUCTION

The **VAPOR CHECK/VAC** oxidation systems origin design was for the soil remediation market. These systems are and can be designed for the elimination of VOC emissions, smoke and odors.

The VAC oxidation units are preengineered for six (6) standard flow rates ranging from 100 SCFM to 1500 SCFM. ThermTech engineers and manufactures custom systems up to 30,000 SCFM. All thermal oxidation equipment is convertible to catalytic operation (low concentrations) with the addition of precious metal catalyst blocks. Vapor extraction systems, heat exchangers, analytical monitors, recorders, telemetry and other equipment can be utilized to maximize performance and operability of each unit, whether the unit is skid (fixed) or trailer mounted (mobile).

The standard **VAC** system operates thermally, raising the process stream temperature from ambient to 1410°F, and retaining the heated vapors for a minimum of 1.0 second to insure proper destruction efficiency before exhausting them to the atmosphere.

The process stream enters the burner chamber through a mechanical diffuser and turbulence generator. These devices insure instant exposure to the internal oxidizer temperature and aid in the development of proper turbulence for proper mixing. The process vapors are retained in the burner chamber for one (1.0) second (twice the EPA recommended one half (0.5) second) to insure maximum destruction efficiency.

The utilities and field erection, wiring and interconnect piping are the responsibility of others.

II QUALITY CONTROL

All phases of the design, engineering, fabrication, assembly and testing are conducted to assure maximum uptime thus resulting in minimal operational and maintenance time.

ThermTech, Inc. personnel inspect all systems for mechanical, operational and maintenance accessibility. This procedure has been developed to insure customer specification compliance from conceptual design through final testing and shipment.

The burner and fuel gas train specified by ThermTech, Inc. are manufactured with Eclipse components. The free substitution of parts to minimize manufacturing cost is not policy. ThermTech encourages the practice of replacing defective parts with the same manufacturer. The Vapor Check system incorporates several components designed to interface with one another for effective and safe operation.

The steel is new and the refractory is top quality, 2400°F ceramic fiber anchored with 310 stainless steel anchors.

ThermTech, Inc. control panels are U.L. Listed, built to meet or exceed U.L. 508A Industrial Control Panel specifications. All panels are built to U.L. type 4 environmental standards as a minimum.

All **VAPOR CHECK** units are functionally tested and thoroughly inspected prior to shipment. This time consuming process insures proper operation in the field. Inspection and test fire procedures have been enclosed in Appendix A of this manual.

The procedure documented above insures the **VAPOR CHECK** system is ready for operation after field installation has been completed.

III GENERAL EQUIPMENT SPECIFICATION

VAC 10

GENERAL DATA

* unit design flow rate	100 SCFM
* burners maximum output	500,000 BTU/hr
* system design BTU	240,000 BTU/hr
* burner turndown ratio	20 to 1
* combustion blower motor size	3/4 HP
* combustion chamber volume	11.25 ft^3
* stack flow area	1 ft^2
* skid dimensions	49" x 123"
* velocity through 4" process inlet	
@ 50 SCFM from process stream	9.5 ft/sec
@ 100 SCFM from process stream	19.1 ft/sec

THERMAL DATA

* combustion blower flow rate at system rating (10% excess air)	44 SCFM
* total exhaust flow rate @ 1400°F	504 ACFM
* burner chamber volume required for 0.5 second retention time @ 1400°F	4.2 ft^3
* burner chamber volume required for 1.0 second retention time @ 1500°F	6.4 ft^3
* stack velocity @ 1400°F	
@ 50 SCFM from process stream	4.2 ft/sec
@ 100 SCFM from process stream	8.4 ft/sec
* estimated weight, thermal unit only	1850 lbs

CATALYTIC DATA

* combustion blower flow rate at system rating (10% excess air)	14 SCFM
* total exhaust flow rate @ 600°F	228 ACFM
* catalyst volume for 95% DRE	0.27 ft^3
* minimum inlet temperature	600°F
* minimum effluent temperature	750°F
* maximum VOC concentrations	25% of the LEL
* maximum effluent temperature	1250°F
* stack velocity @ 600°F	
@ 50 SCFM from process stream	1.9 ft/sec
@ 100 SCFM from process stream	3.8 ft/sec
* estimated weight, thermal unit plus catalytic module (95% destruction)	1915 lbs

* The above data is typical design criteria. Specific job/unit information can be obtained by end user from ThermTech, Inc..

VAC 25

GENERAL DATA

* unit design flow rate	250 SCFM
* burners maximum output	1.0 mmBTU/hr
* system design BTU	0.6 mmBTU/hr
* burner turndown ratio	20 to 1
* combustion blower motor size	1 HP
* combustion chamber volume	25.31 ft^3
* stack flow area	1 ft^2
* skid dimensions	58" x 136"
* velocity through 4" process inlet	
@ 125 SCFM from process stream	23.8 ft/sec
@ 250 SCFM from process stream	47.5 ft/sec

THERMAL DATA

* combustion blower flow rate at system rating (10% excess air)	110 SCFM
* total exhaust flow rate @ 1400°F	1260 ACFM
* burner chamber volume required for 0.5 second retention time @ 1400°F	10.5 ft^3
* burner chamber volume required for 1.0 second retention time @ 1500°F	16.1 ft^3
* stack velocity @ 1400°F	
@ 125 SCFM from process stream	10.5 ft/sec
@ 250 SCFM from process stream	21.0 ft/sec
* estimated weight, thermal unit only	2200 lbs

CATALYTIC DATA

* combustion blower flow rate at system rating (10% excess air)	31 SCFM
* total exhaust flow rate @ 600°F	562 ACFM
* catalyst volume for 95% DRE	0.54 ft^3
* minimum inlet temperature	600°F
* minimum effluent temperature	750°F
* maximum VOC concentrations	25% of the LEL
* maximum effluent temperature	1250°F
* stack velocity @ 600°F	
@ 125 SCFM from process stream	4.7 ft/sec
@ 250 SCFM from process stream	9.4 ft/sec
* estimated weight, thermal unit plus catalytic module (95% destruction)	2315 lbs

* The above data is typical design criteria. Specific job/unit information can be obtained by end user from ThermTech, Inc..

VAC 50

GENERAL DATA

* unit design flow rate	500 SCFM
* burners maximum output	1.5 mmBTU/hr
* system design BTU	1.2 mmBTU/hr
* burner turndown ratio	20 to 1
* combustion blower motor size	1 HP
* combustion chamber volume	45 ft^3
* stack flow area	1 ft^2
* skid dimensions	67" x 136"
* velocity through 4" process inlet	
@ 250 SCFM from process stream	47.7 ft/sec
@ 500 SCFM from process stream	95.5 ft/sec

THERMAL DATA

* combustion blower flow rate at system rating (10% excess air)	220 SCFM
* total exhaust flow rate @ 1400°F	2520 ACFM
* burner chamber volume required for 0.5 second retention time @ 1400°F	21.0 ft^3
* burner chamber volume required for 1.0 second retention time @ 1500°F	32.0 ft^3
* stack velocity @ 1400°F	
@ 250 SCFM from process stream	21.0 ft/sec
@ 500 SCFM from process stream	42.0 ft/sec
* estimated weight, thermal unit only	2500 lbs

CATALYTIC DATA

* combustion blower flow rate at system rating (10% excess air)	64 SCFM
* total exhaust flow rate @ 600°F	1122 ACFM
* catalyst volume for 95% DRE	0.81 ft^3
* minimum inlet temperature	600°F
* minimum effluent temperature	750°F
* maximum VOC concentrations	25% of the LEL
* maximum effluent temperature	1250°F
* stack velocity @ 600°F	
@ 250 SCFM from process stream	9.4 ft/sec
@ 500 SCFM from process stream	18.7 ft/sec
* estimated weight, thermal unit plus catalytic module (95% destruction)	2700 lbs

* The above data is typical design criteria. Specific job/unit information can be obtained by end user from ThermTech, Inc..

VAC 75

GENERAL DATA

* unit design flow rate	750 SCFM
* burners maximum output	3.0 mmBTU/hr
* system design BTU	1.8 mmBTU/hr
* burner turndown ratio	20 to 1
* combustion blower motor size	3 HP
* combustion chamber volume	73.5 ft^3
* stack flow area	2 ft^2
* skid dimensions	77" x 144"
* velocity through 6" process inlet	
@ 375 SCFM from process stream	31.9 ft/sec
@ 750 SCFM from process stream	63.7 ft/sec

THERMAL DATA

* combustion blower flow rate at system rating (10% excess air)	330 SCFM
* total exhaust flow rate @ 1400°F	3780 ACFM
* burner chamber volume required for 0.5 second retention time @ 1400°F	31.5 ft^3
* burner chamber volume required for 1.0 second retention time @ 1500°F	48.3 ft^3
* stack velocity @ 1400°F	
@ 375 SCFM from process stream	15.8 ft/sec
@ 750 SCFM from process stream	31.5 ft/sec
* estimated weight, thermal unit only	3000 lbs

CATALYTIC DATA

* combustion blower flow rate at system rating (10% excess air)	100 SCFM
* total exhaust flow rate @ 600°F	1700 ACFM
* catalyst volume for 95% DRE	0.92 ft^3
* minimum inlet temperature	600°F
* minimum effluent temperature	750°F
* maximum VOC concentrations	25% of the LEL
* maximum effluent temperature	1250°F
* stack velocity @ 600°F	
@ 375 SCFM from process stream	7.1 ft/sec
@ 750 SCFM from process stream	14.2 ft/sec
* estimated weight, thermal unit plus catalytic module (95% destruction)	3230 lbs

* The above data is typical design criteria. Specific job/unit information can be obtained by end user from ThermTech, Inc..

VAC 150

GENERAL DATA

* unit design flow rate	1500 SCFM
* burners maximum output	6.0 mmBTU/hr
* system design BTU	3.6 mmBTU/hr
* burner turndown ratio	20 to 1
* combustion blower motor size	5 HP
* combustion chamber volume	128 ft^3
* stack flow area	3.5 ft^2
* skid dimensions	79" x 193"
* velocity through 8" process inlet	
@ 750 SCFM from process stream	36.0 ft/sec
@ 1500 SCFM from process stream	72.0 ft/sec

THERMAL DATA

* combustion blower flow rate at system rating (10% excess air)	660 SCFM
* total exhaust flow rate @ 1400°F	7560 ACFM
* burner chamber volume required for 0.5 second retention time @ 1400°F	63 ft^3
* burner chamber volume required for 1.0 second retention time @ 1500°F	97 ft^3
* stack velocity @ 1400°F	
@ 750 SCFM from process stream	18.0 ft/sec
@ 1000 SCFM from process stream	36.0 ft/sec
* estimated weight, thermal unit only	4100 lbs

CATALYTIC DATA

* combustion blower flow rate at system rating (10% excess air)	202 SCFM
* total exhaust flow rate @ 600°F	3404 ACFM
* catalyst volume for 95% DRE	1.92 ft^3
* minimum inlet temperature	600°F
* minimum effluent temperature	750°F
* maximum VOC concentrations	25% of the LEL
* maximum effluent temperature	1250°F
* stack velocity @ 600°F	
@ 750 SCFM from process stream	8.1 ft/sec
@ 1000 SCFM from process stream	16.2 ft/sec
* estimated weight, thermal unit plus catalytic module (95% destruction)	4325 lbs

* The above data is typical design criteria. Specific job/unit information can be obtained by end user from ThermTech, Inc..

IV HANDLING INSTALLATION, AND STORAGE

A. Handling

Crating and shipping preparation has been maximized to assure the unit arrives on site in the same condition as it left ThermTech. Upon delivery of the unit, inspect the unit fully. If damage has occurred during shipment, damaged components are to be noted on the receiving slip. This procedure must be followed to financially protect both yourself and ThermTech against damage occurred during shipment. Prior to accepting/signing the receiving slip, review packing list and verify all components have been received. An acceptable practice is to sign the receiving slip `OK pending further investigation'. Notify ThermTech, Inc. **immediately** in the unlikely event of damaged or missing components.

The crate(s) can be unloaded with a fork truck or crane. The forks of the fork lift must span under the entire skid for lifting to prevent damage to the system. Lifting lugs have been provided for lifting with a crane. Uncrating the system may be required before lifting with a crane. The use of spreader bars is required to prevent damage.

B. Installation

The skid is designed as a stand alone piece of equipment or can be integrated to interface with individual pieces of process equipment. There are several required field connections prior to starting the unit.

1. The oxidizer system skid must be leveled, stabilized, and anchored in place to meet all local codes. For systems purchased with the trailer option, four (4) jack stands and one (1) jack have been supplied for stabilizing the trailer.

2. The stack section(s) need installed. Refer to the instructions in the stack installation kit to install each stack. The stack, while self-supporting, should be guy wired to eliminate the possibility of the unit over turning or moving during adverse environmental conditions, i.e. high winds. It is recommended that turnbuckles be incorporated in the guy lines for adequate adjustment. Contact ThermTech for written installation recommendations and guidelines for stack extensions over 10 ft.

3. The fuel gas supply line attaches to the inlet orifice of the gas train. A minimum of five (5) psig and a maximum of forty (40) psig inlet pressure at the skid limits is needed for proper and safe operation. Refer to the P&ID (section XII) for the required BTU value needed for the system.

4. The skid electrical power connects to the system disconnect. The power requirement is detailed on the one line wiring diagrams (section XII) and must be followed. ThermTech requests that only qualified personnel complete this task as electrical shock could result.

5. Interconnecting signal field wiring must be installed to properly integrate each skid into the entire process. Control schematics showing field wiring (section XII) must be followed to insure proper operation of the entire system.

6. Review the entire system. Larger systems may require the combustion air blower inlet pipe spool and/or the filter to be removed for shipment. The packing list will detail the pipe spool and/or the filter and hardware if field installation is required.

7. Process piping must be connected to the flange provided. Refer to the general arrangement drawing (section XII) for location and size.

8. A storage vessel (customer supplied) will need to be connected to the KO pot drain piping (VES option only).

9. The high temperature dilution air valve, supplied by ThermTech, Inc., must be installed (base oxidizer only). Install the valve on the inlet side of the process blower (by others) on a tee/lateral to ambient air. A filter (by others) is recommended to be installed on the inlet to valve.

C. Storage

Protection of the system from elements of nature entering the system during storage is mandatory. Various component manufacturers require special procedures during storage to prevent damage. The following is a minimum requirement for storage.

1. All flanged piping connections should be covered with a blind flange or equal and secured.

2. All threaded piping connections should be plugged.

3. All electrical enclosures should have openings plugged and desiccant packages inserted in the interior of the enclosures, panels and components, to minimize the possibility of condensation.

4. All stack openings should be covered with plywood or equal and secured.

5. Refer to blower manuals for manufacturer requirements for storage, i.e. rotation requirements, winterizing.

V GENERAL EQUIPMENT DESCRIPTION

A. Thermal/Catalytic Oxidizer

1. Oxidizer

The oxidizer has been designed to effectively destroy hydrocarbons with minimal operational personnel and utility usage.

Hydrocarbon laden air is fed to the skid via a process blower at fifteen (15) inches wc (or greater). The vapors then enter or bypass the heat exchanger device (if applicable) depending upon hydrocarbon concentration (description below). Prior to entering the oxidation chamber, an inline flame arrester has been incorporated to prevent flashback from the chamber into the process piping.

The process stream enters the oxidizer where the vapors are thoroughly mixed and heated to operating temperature. Thermal operation will require the vapors to be held at temperature for a minimum of one (1) second to guarantee proper destruction efficiency.

Catalytic operation (if applicable) will have a significantly lower oxidizer temperature as the oxidizer chamber is used as a preheat device. Once the hydrocarbon stream has reached operation temperature the stream passes thru the catalyst module where hydrocarbon destruction will occur.

Both thermal and catalytic operations will have the hot flue gases pass thru the heat exchanger (if applicable) prior to being expelled to the atmosphere.

2. Heat Exchanger (if applicable)

The heat exchanger is shipped mounted in place with all interconnecting piping in place. A bypass valving arrangement has been incorporated to minimize fuel usage.

VALVE 1: An inline valve at the inlet to the heat exchanger. This valve has been set so the maximum closure is approximately 90-95%. This is to allow enough air flow through the inlet transition and expansion joint to dissipate heat from the heat exchanger which could result in scored paint or damage to the expansion joint.

VALVE 2: The valve connecting the inlet and outlet piping of the heat exchanger.

The advantage of bypassing the heat exchanger is to maximize the clean-up of hydrocarbons. If high VOC concentrations exist initially, the operator would bypass the heat exchanger and put as much as 80% of the LEL into the oxidizer, if local codes permit. As the concentrations decrease, flow rate through the heat exchanger would need to increase.

B. Vapor Extraction System (if applicable)

The hydrocarbon laden vapors are pulled from the soil to the system skid utilizing a vacuum blower. A bypass valve (if applicable) is utilized as a secondary flow control device to fine tune flow control because soil composition and porosity vary.

The process vapors enter the skid and are pulled thru a moisture separator. This knock out pot has been designed to removed 99% of the entrained liquids and particulate matter from the process stream.

A manual dilution valve and an automatic dilution valve (if applicable) is located on the inlet of the knock out pot. These valve's function is to dilute extremely high concentrated vapor streams. This dilution process is necessary to properly maintain the operating temperature of the oxidizer and minimize high temperature shutdowns.

A process line block valve (if applicable) is used to disallow the flow of hydrocarbon laden air to the oxidizer prior to main fuel gas being brought to the oxidizer. The motorized high temperature dilution air valve allows ambient air into the system and will not shut until proper operating temperature is reached, thus minimizing the flow rate from the process.

Several indicators are used to monitor the process through the VES, i.e. process stream temperature, total flow to oxidizer, total well vacuum, total pressure (if applicable), dilution air flow rate (if applicable) and delta p across KO pot (if applicable).

VI OPERATION

A. Oxidizer

1. Turn main power on to the control panel via the system disconnect.

2. Reset the emergency stop push button (PB1). The combustion blower (B-1003) will turn on.

3. Reset the power interruption circuitry via the push button (PB3) on the front of the oxidizer control panel.

4. Reset alarms via the push button (PB2) on the front of the control panel.

5. Turn the on/off selector switch (SS1) to on and the run/low fire switch (SS2) to low fire.

   A timed air purge of the combustion chamber is initiated. The temperature control valve (TCV202) will drive open allowing maximum combustion air flow. The timed air purge (via T2 and BY502) allows for a minimum of six (6) volume changes of the chamber before proceeding.

   Once T2 times out and the combustion air flow valve (TCV202) moves to low fire, the pilot solenoid (XV101) will energize (open) and pilot ignition sequence will start.

   The flame safety system (BY502) proves flame, the main fuel gas solenoid (XV105) will energize (open). If flame or ignition is not proven, the system will shut down on flame failure.

6. Assuming pilot is lit.

   The process blowers will turn on when the chamber temperature reaches 140°F. The system will then prove process flow (PSL310) from the process blower or will shut down if flow is not proven.

   Manually reset (open) the "locktite" main gas valve (XV104), and turn the run/low fire switch (SS2) to the run.

The main burner is ignited at low fire and will increase flame intensity until high fire or until the set point of the temperature controller (TIC503A) is reached. Once the combustion chamber temperature is at set point, the burner system will continue to modulate to maintain the set point.

7. See Section VIII for notes on Heat Exchanger heat up.

Note: **If this sequence is not followed, the entire system will either shut down or refuse to proceed any further. Pilot lights are provided on the panel to indicate system status.**

This unit was factory set to operate on natural gas. If propane is the selected fuel, review Section VI, C for proper adjustments. The propane used must be free of propylene to insure proper destructive efficiency.

B. Operation of VES System

The operation of the thermal and/or catalytic unit remains the same as previously described. The VES system incorporates additional safety and control features.

1. The manual flow control valve (if applicable) between the knock out pot and the process flange must be closed and the manual dilution air valve must be open.

2. When the main gas solenoid valve opens during start up (section VI, page 1), the process shutdown valve (XV304) (if applicable) will be energized and can be opened.

3. Once at operating temperature, gradually open the flow control valve between the knock out pot and the process flange, checking the high temperature shut down controller (TISH504A) to insure excessive amounts of hydrocarbon do not enter the system. Excessive amounts of hydrocarbons will increase the temperature. After the flow control valve is fully open, gradually shut the manual dilution air valve while observing the high temperature controller (TISH504A). This will allow a vacuum to be applied to the process and

hydrocarbons pulled into the system. The total air flow (FI309) to the oxidizer should not exceed the rated capacity of the oxidizer.

NOTE: If extremely high hydrocarbon concentrations are introduced into the system, the temperature will increase and at 1500°F the system will shut down on a high temperature shut down and the entire startup procedure must be repeated.

4. Main VES components

a. Flow Control Valve (BF-1)(if applicable)

A manual butterfly valve, located in line between KO pot (V-1001) and process flange, is utilized to control flow from the process.

b. Manual Dilution Air Valve (BF-1)

A manual butterfly valve is used to introduce dilution air to the system and aid in controlling vacuum being applied to the process. The valve is located on the inlet side of the KO pot (V-1001).

c. Automatic Dilution Air Valve (TCV400) (if applicable)

An automatic valve used to control temperature via controlling the flow of dilution air. This valve is used once operating temperature has been reached. TCV400 modulates via a 4-20mA signal from the automatic dilution temperature controller (TIC504B) sensing temperature at TE504B.

d. Moisture separator (V-1001)

Removes water and particulate matter from the process stream. Heat tracing and insulation (if applicable) has been incorporated to prevent freezing. A high liquid level switch (LSHH303) installed will shut down the system should the liquid level exceed design criteria. This alarm must be cleared prior to restarting the system. The knockout pot is equipped with a automatic drain system (if applicable) to maintain proper operating levels (LSH303/LSL303). A storage container (by others) is needed for liquids discharged.

NOTE: If the high liquid level shut down switch (LSHH303) fails to operate and the V-1001 is full of water, moisture could be drawn through the vapor extraction system and into the combustion chamber. However, the moisture will plug the process air flow switch (PSL310) sensing tube in the process stream.

The line plugged, PSL310 will fail to sense the process air flow and the system will shut down on process blower failure.

Any moisture that accumulates in the combustion chamber will be driven off at the combustion chamber operating temperature; or as the combustion chamber is brought back up to operating temperature. The moisture will not damage the ceramic fiber insulation due to the high porosity of the fiber. Ceramic fiber is extremely resilient to thermal shock.

Should raw product be drawn from the wells, this liquid raw product can never reach the combustion chamber. First, the blowers generally can not draw a solid head of liquid through the piping. A solid stream, less than 5% of the pipe diameter, could be pulled through the pipe. As this liquid moves to the surface, it will be preceded by the less dense vapor/air stream. The concentrations of hydrocarbons in this process stream will increase as the hydrocarbons are stripped from the raw product. This hydrocarbon increase will cause the combustion chamber temperature to rise, possibly exceeding the system high temperature limits and shut down. As with all ThermTech system shut downs, the burner system will shutdown, the high temperature dilution air valve will open and if applicable, the fail safe valve in the process stream shuts eliminating the wells, knock out pot, and all sources of fuel from the process. After any shut down, the system will purge using both the process and combustion blowers. This thirty (30) minute purge completes a combustion chamber volume change approximately every second or 1800 volume changes.

e. Fail Close Valve (XV304)(if applicable)

A safety valve incorporated into the "VES" system to insure no vapors can be introduced before reaching operating temperature and on system shut downs.

f. High Temperature Dilution Air Valve (TCV600)

An open/closed motor operated butterfly valve utilized to allow fresh air to the oxidizer below operating temperatures. This valve insures minimum vacuum to the process prior to the system establishing operational temperature and in the event of a high temperature shut down.

g. Vacuum relief valve (PVSV305)

Designed, sized and set to prevent overloading the process blower(s) (B-1002).

h. Process Blower(s) (B-1002)

Specified and installed by ThermTech to meet customers requirements.

i. Bypass valve (BF-2)(if applicable)

A manual butterfly valve connecting B-1002 outlet to the inlet. The valve is a secondary flow control valve and offers a more refined means to control flow.

NOTE: The recirculation valve, when utilized, may cause the process stream temperature to increase. If this temperature is allowed to increase above 250°F, damage to the process blower could occur and will require replacement. This replacement should be performed by factory trained personnel only.

j. Flow control valve (BF-1)

A manual butterfly valve utilized for primary flow control, installed on the inlet side of B-1002.

k. Flame Arrestor

Installed to prevent flash back into the process stream from the oxidizer.

l. Magnehelics/Gages

There are numerous magnehelics/gages installed to monitor the operation of the system.

m. Sample Ports

There are three (3) sample ports (⅛" gage cocks) in the process stream. One is located at B-1002 discharge and inlet and one at the process flange.

C. Burner Adjustment

1. Combustion Air and Fuel Gas Flow Measurements

a. Combustion air flow through the burner is determined by measuring the differential pressure (PDI501) across taps "A" and "C" on the burner. Burner data sheets are in the back of this section.

b. Fuel gas flow is determined by measuring the differential pressure (FI107) across the metering orifice (FE107) located in the fuel gas line before the proportionator (FCV108). Flow curves are located in the back of this section.

2. Initial Start-up

a. Close all manual, adjustment, and automatic gas valves.

b. Set linkage between actuator & butterfly valve (TCV202), the valve in the combustion air line located between the combustion air blower and the burner. Turn power on, reset the emergency stop, power interruption and alarms. Turn the oxidizer run/low fire switch (SS2) to the low fire. Position the control arm on the actuator shaft at the 90° direction (pointing up) and hand tighten. Turn SS2 to run. The actuator will rotate 90°

counter-clockwise. Position the disc in the control valve to be open 100% (slot in valve shaft is horizontal) and mount the control arm on the valve shaft pointing to the seven (7) or eight (8) o'clock position, hand tighten. Bolt one swivel to each control arm and slide the linkage rod through the swivels and hand tighten. Turn SS2 to low fire. The valve and actuator will rotate clockwise. Adjust the linkage so the valve will be approximately 75% closed (slot in shaft is at approximately the eleven (11) o'clock position). Cycle back and forth between run and low fire a few times to verify positioning and to insure no binding of the valve and/or actuator. Tighten linkage bolts.

c. Close the manual air valve (BF-4) at the burner.

d. Insure the combustion blower (B-1003) is running.

* e. Drive the control actuator (TCV202) to high fire (SS2 to run). Measuring the air flow as described in step 1a, open the manual air valve (BF-4) on the burner until the desired setting is reached. Burner air flow curves are located in the back of this section.

* f. Drive TCV202 to low fire (SS2 to low fire). Measuring combustion air flow as detailed in step 1a, adjust the linkage rod on the TCV202 to achieve the desired low fire air flow, slide rod up to decrease and down to increase air flow.

* g. Cycle between steps 2e and 2f to insure the settings are correct.

* h. Tighten all linkage bolts.

* i. Turn SS2 to run. Turn the four-way valve (BV-6) at the proportionator (FCV108) to point to the six (6) o'clock position. Measure the proportionator impulse air pressure on PI109 and record the pressure reading for use in step 2n. Turn SS2 to low fire and check the pressure on PI109. This pressure at low fire

should be no more than 3" wc.

* j. Turn SS2 to low fire.

* k. Open valves to allow fuel gas flow through the pilot line (the smaller line). Open pilot gas adjustable orifice shutoff cock (BV-3), remove the cap in the center of the stem. Inside the stem is an adjustment screw. As a starting point, turn the screw all the way in (closed) then back out 4 complete turns; this will allow the pilot to light.

* l. Turn on/off switch (SS1) to on. After the purge cycle is completed, pilot should lite. Adjust screw in step 2k as closed as possible without losing the pilot. The DC voltmeter on the control panel will be advantageous for this adjustment. Set the pilot so that the DC voltage is not less than 10 volts. Pilot should blow out at high fire (run position) but also relight without adjustment of any valves.

* m. Reset (open) the manual reset valve (XV104) once the main gas solenoid (XV105) is energized.

* n. Measure gas pressure at inlet side to the proportionator (FCV108). Turn the four-way valve (BV-6) to point to the nine (9) o'clock position. Adjust the main gas line pressure regulator (PCV102) to the required inlet gas differential pressure. Refer to the adjustable bias proportionator data sheets in the back of this section for how much higher in pressure the fuel gas should be than the air impulse pressure measured in step 2i.

* o. Turn SS2 to run. Remove cap from adjustable limiting orifice (NV-1) on the burner. The temperature controller (TIC503A) incorporates a timed ramp feature which controls the process variable temperature rise from 200°F to 1410°F in twenty (20) minutes. Monitoring the process variable and the ramp temperature (both displayed on TIC503A), adjust NV-1 so the process variable increases with the ramp temperature. When the oxidizer reaches its

1410°F setpoint and if the TCV202 is open 100%, then open NV-1 more to cause TCV202 to close some. This will insure maximum control of the system. Measure the fuel gas flow as described in step 1b. Metering orifice flow curves are located in the back of this section. At various times during the ramp, measure the combustion air and fuel gas flow rate and compare the two volumes to insure there at least 10% excess air at all times.

* p. Turn SS2 to low fire.

* q. Measuring the differential pressure across the inlet and outlet sides of the proportionator (FCV108) in low fire, adjust the bias adjusting screw of FCV108 to be not less than 2" WC or greater than 56" WC. The greater the differential pressure, the better control of the burner at low fire.

NOTE: Air impulse line to FCV108 should be approximately 0 to 3" WC higher than outlet fuel gas pressure.

* r. Using fuel gas analysis or metering orifices or visual flame appearance, adjust bias to the desired low fire fuel/air ratio - keeping in mind step 2q.

* These steps are for adjustments after initial start-up. Valves in certain steps may already be open so only final adjustments may be necessary.

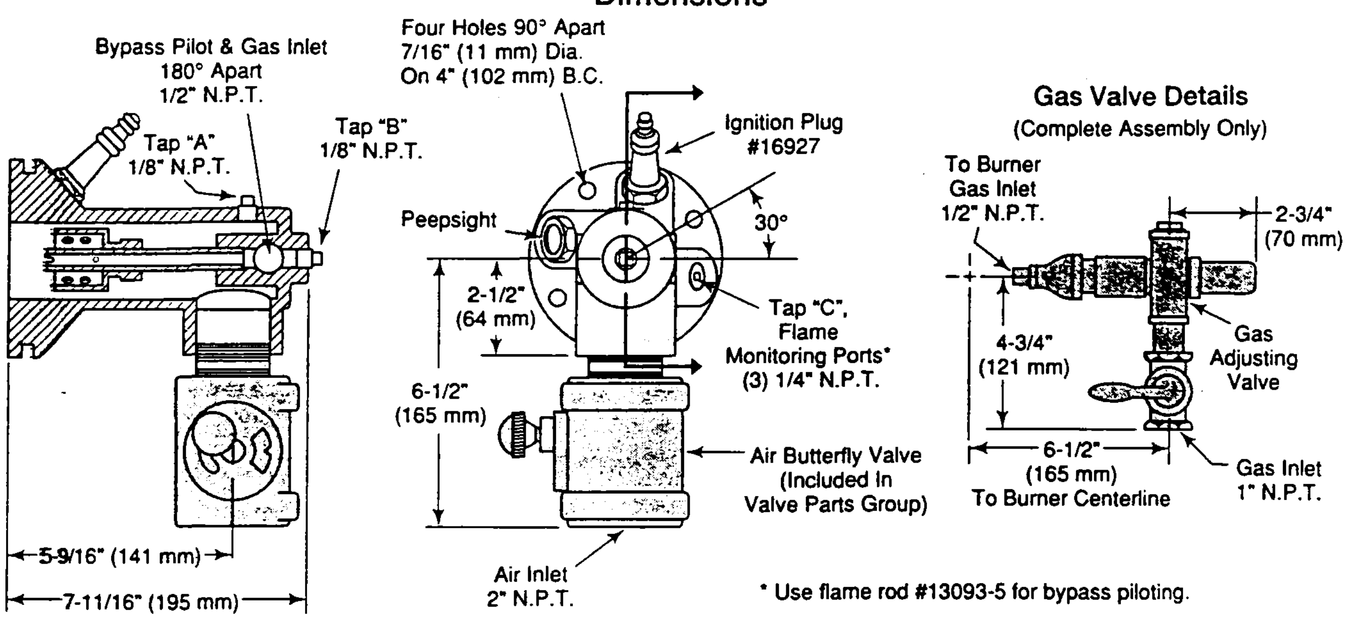
*** Guides - These adjustments are accurate settings; however, like setting a carburetor on an older car, factory recommendations are settings that the equipment will work very efficiently and safely. But, because of other parameters such as altitude, humidity, barometric pressure, etc. minor changes to these adjustments may further refine fuel consumption, flame temperature, etc. to optimize system operation.

NOTE: **THE TEMPERATURE IN THE OXIDIZER SHOULD NOT EXCEED 250°F WITH PILOT FLAME ONLY, LOCKTITE VALVE (XV104) RESET (OPEN), AND SS2 IN LOW FIRE.**

ECLIPSE DATA SHEET
82 MVTA

Data 215-2
6/93
formerly H-44-2

Dimensions



* Use flame rod #13093-5 for bypass piloting.

= Burner Assembly #102880. A block and holder assembly must be ordered as a separate item. An alloy combustion tube or silicon carbide tube may be ordered instead of a block and holder.

= Items included in the Valve Parts Group #102887.

CAUTION: It is dangerous to use any fuel burning equipment unless it is equipped with suitable flame sensing devices and automatic fuel shut-off valves. Eclipse can supply such equipment or information on alternate sources.

Capacities
Using Natural Gas - 0.6 Sp. Gr.

		Combustion Air Flow in SCFH	500	1000	2000	3000	4000	5000
English Units	On-Ratio Operation	Static Air Press. at Tap "A," "w.c.	0.1	0.4	1.3	2.45	4.2	5.7
		Air ΔP Between Taps "A" & "C," "w.c.	0.06	0.25	0.9	1.6	2.9	3.9
		Static Gas Press. at Tap "B," "w.c. *	0.1	0.3	0.9	2.0	3.1	4.3
		Gas ΔP Between Taps "B" & "C," "w.c.	0.07	0.18	0.55	1.1	1.6	2.45
		Capacity in 1000's Btu/Hr.	50	100	200	300	400	500
		Approx. Flame Length, Inches	26	30	36	36	36	42
	Excess Air Operation	Minimum Gas Flow, SCFH	15	15	45	45	70	70
		% Excess Air	230	570	430	660	560	610
Metric Units**		Combustion Air Flow in Nm³/hr.	13	27	54	80	107	134
	On-Ratio Operation	Static Air Press. at Tap "A," Pa.	25	97	324	610	1046	1420
		Air ΔP Between Taps "A" & "C," Pa.	15	62	224	399	722	972
		Static Gas Press. at Tap "B," Pa. *	25	75	224	498	772	324
		Gas ΔP Between Taps "B" & "C," Pa.	17	45	137	274	399	610
		Capacity in 1000's kJ/hr.	53	106	211	317	422	528
		Approx. Flame Length, mm	660	762	914	914	914	1067
	Excess Air Operation	Minimum Capacity, kJ/hr. in 1000's	16	16	47	47	74	74
		% Excess Air	230	570	430	660	560	610

* For burner less parts group. For burner with parts group, the required gas pressure at high fire to the gas valve (not Tap "B") is 6.3" w.c. (1569 Pa.). Gas ΔP between taps "B" and "C" remains unchanged.
Size bypass pilot piping and accessories to ensure 2" w.c. (498 Pa.) at the burner pilot gas connection.

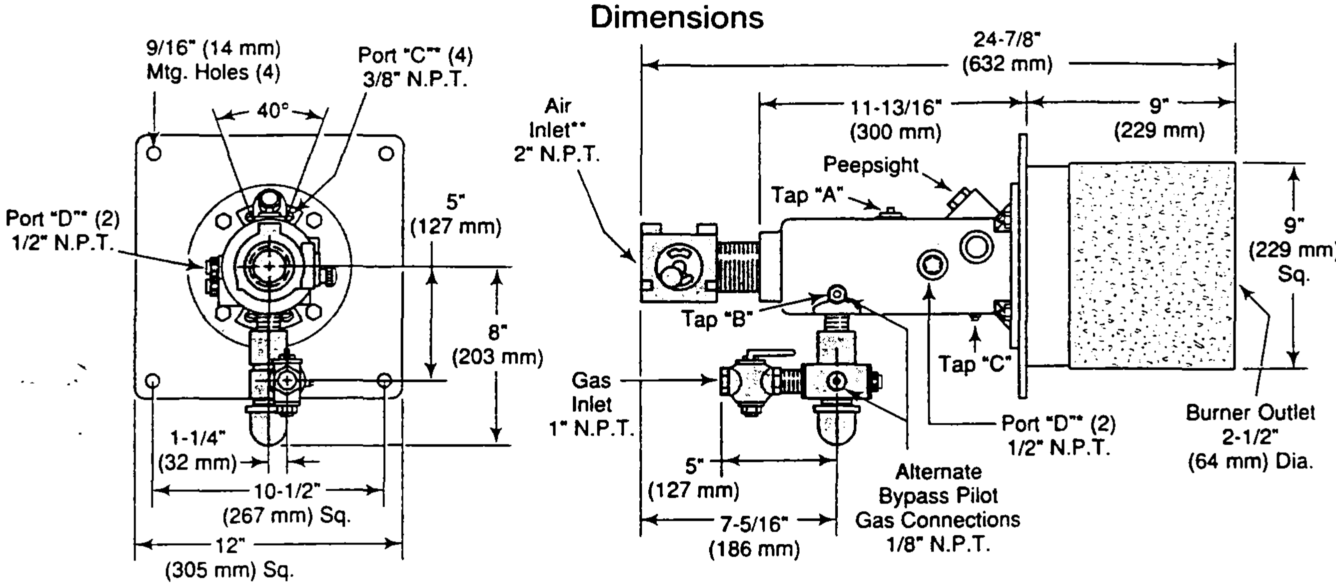
** 100 Pa. (Pascal) = 1 mbar = 9.8 mm w.c.

Eclipse
ECLIPSE COMBUSTION
ROCKFORD, ILLINOIS 61103 (815) 877-3031
CANADA: ECLIPSE THERMAL SYSTEMS

ECLIPSE DATA SHEET
84 MVTA

Data 215-3
8/90
formerly H-44-2

Dimensions



* NMP-S pilot with adaptor (#11969) may be connected to any of ports "C". When NMP-S pilot is used, flame rod (#13093-3) or U.V. scanner must be connected to the port "C" adjacent to the pilot connection. For bypass pilot, use ignition plug (#16946-5) in either of ports "D". Flame rod or U.V. scanner may then be connected to any of ports "C". Flame rod mounting requires a 1/4" x 3/8" bushing.

** Eclipse recommends air piping and components of at least 3" N.P.T. diameter to avoid excessive velocity pressure losses. Pipe size should be reduced from 3" to 2" as close to the burner as possible.

= Burner Assembly #102881. Although the block and holder assembly is illustrated as part of the burner, it must be ordered as a separate item. An alloy combustion tube or silicon carbide tube may be ordered instead of a block and holder.

= Items included in the Valve Parts Group #102888.

CAUTION: It is dangerous to use any fuel burning equipment unless it is equipped with suitable flame sensing devices and automatic fuel shut-off valves. Eclipse can supply such equipment or information on alternate sources.

Capacities
Using Natural Gas - 0.6 Sp. Gr.

English Units		Combustion Air Flow in SCFH	1000	2000	4000	6000	8000	10,000
	On-Ratio Operation	Static Air Press. at Tap "A," "w.c.	0.15	0.5	1.4	3.0	5.4	7.8
		Air ΔP Between Taps "A" & "C," "w.c.	0.08	0.25	0.75	1.5	2.7	3.9
		Static Gas Press. at Tap "B," "w.c. *	0.1	0.25	0.8	1.7	3.0	4.3
		Gas ΔP Between Taps "B" & "C," "w.c. **	—	0.05	0.15	0.25	0.35	0.65
		Capacity in 1000's Btu/Hr.	100	200	400	600	800	1000
		Approx. Flame Length, Inches	18	18	30	33	33	33
	Excess Air Operation	Minimum Gas Flow, SCFH	10	20	35	55	75	95
		% Excess Air	900	900	1050	990	970	1010
Metric Units†		Combustion Air Flow in Nm³/hr.	27	54	107	161	214	268
	On-Ratio Operation	Static Air Press. at Tap "A," Pa.	37	125	349	747	1345	1943
		Air ΔP Between Taps "A" & "C," Pa.	20	62	187	374	673	971
		Static Gas Press. at Tap "B," Pa. *	24.9	62	199	423	747	1071
		Gas ΔP Between Taps "B" & "C," Pa. **	—	12	37	62	87	162
		Capacity in 1000's kJ/hr.	106	211	422	633	844	1055
		Approx. Flame Length, mm	457	457	762	838	838	838
	Excess Air Operation	Minimum Capacity, kJ/hr. in 1000's	11	22	37	58	79	100
		% Excess Air	900	900	1050	990	970	1010

* For burner less parts group. For burner with parts group, the required gas pressure at high fire to the gas valve (not Tap "B") is 11" w.c. (2740 Pa.). Gas ΔP between taps "B" and "C" remains unchanged.
Size bypass pilot piping and accessories to ensure 2" w.c. (498 Pa.) at the burner pilot gas connection.

** Due to low pressure drops across the burner, use a separate metering orifice for burner set-up & adjustment.

† 100 Pa. (Pascal) = 1 mbar = 9.8 mm w.c.

ECLIPSE COMBUSTION
ROCKFORD, ILLINOIS 61103 (815) 877-3031
CANADA: ECLIPSE THERMAL SYSTEMS
HOLLAND: FLAMECO-ECLIPSE
ENGLAND: ECLIPSE THERMAL SYSTEMS

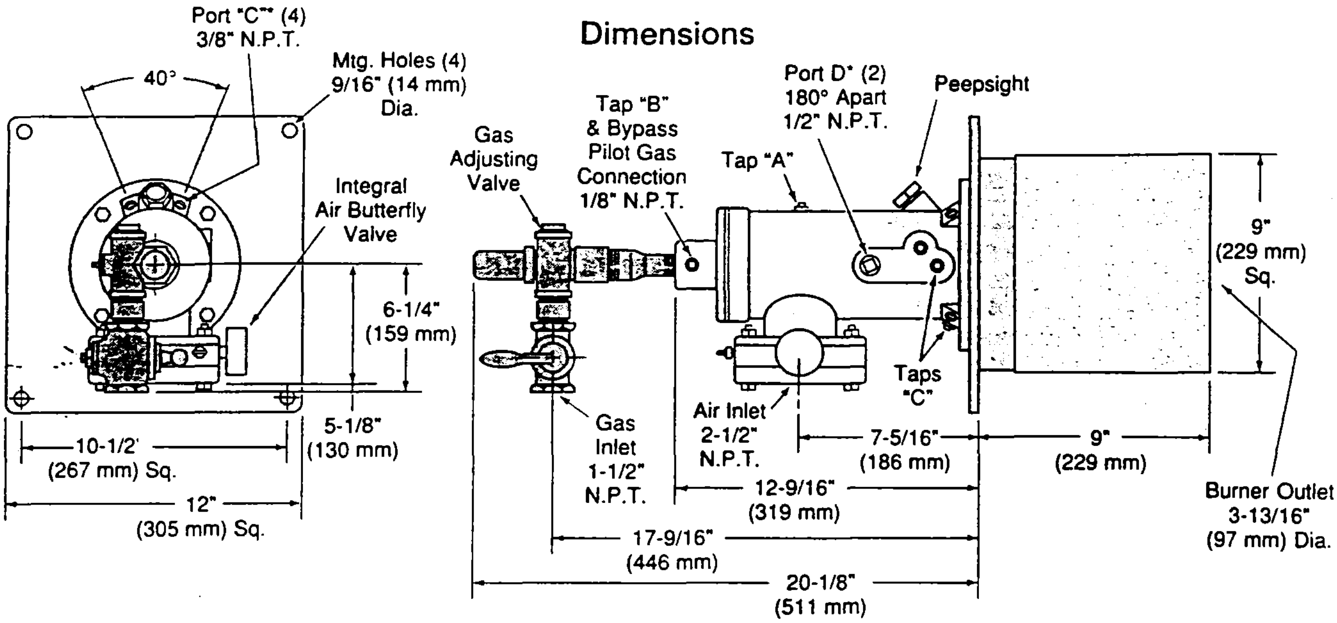
ECLIPSE DATA SHEET

104 MVTA

Data 215-4

4/90

Dimensions



* NMP-S pilot with adaptor (#11969) may be connected to any of ports "C". When NMP-S pilot is used, flame rod (#13093-3) or U.V. scanner must be connected to the port "C" 40° adjacent to the pilot connection. For bypass pilot, use ignition plug (#18193-1) in either of ports "D". Flame rod or U.V. scanner may then be connected to any of ports "C". Flame rod mounting requires a 1/4" x 3/8" bushing.

= Burner Assembly #102882. Although the block and holder assembly is illustrated as part of the burner, it must be ordered as a separate item. An alloy combustion tube may be ordered instead of a block and holder.

= Items included in Valve Parts Group #102889.

CAUTION: It is dangerous to use any fuel burning equipment unless it is equipped with suitable flame sensing devices and automatic fuel shut-off valves. Eclipse can supply such equipment or information on alternate sources.

Capacities

Using Natural Gas - 0.6 Sp. Gr.

English Units		Combustion Air Flow in 1000's SCFH	1.5	3	6	9	12	15
	On-Ratio Operation	Static Air Press. at Tap "A," "w.c.	0.35	1.7	2.8	5.3	8.7	12.9
		Air ΔP Between Taps "A" & "C," "w.c.	0.15	0.7	1.4	3.1	4.5	5.9
		Static Gas Press. at Tap "B," "w.c.	0.2	0.7	1.9	3.7	5.3	8.3
		Gas ΔP Between Taps "B" & "C," "w.c.	0.0	0.05	0.3	0.55	0.9	1.3
		Capacity in 1000's Btu/Hr.	150	300	600	900	1200	1500
		Approx. Flame Length, Inches	23	35	42	48	52	55
	Excess Air Operation	Minimum Gas Flow, SCFH	25	30	50	78	95	100
		% Excess Air	500	900	1100	1050	1160	1400
Metric Units†		Combustion Air Flow in Nm³/hr.	40	80	161	241	322	402
	On-Ratio Operation	Static Air Press. at Tap "A," Pa.	87	423	698	1320	2167	3214
		Air ΔP Between Taps "A" & "C," Pa.	37	174	349	772	1121	1470
		Static Gas Press. at Tap "B," Pa. *	50	174	473	922	1395	2068
		Gas ΔP Between Taps "B" & "C," Pa. **	0	13	75	137	224	324
		Capacity in 1000's kJ/hr.	158	316	633	949	1266	1582
		Approx. Flame Length, mm	584	889	1067	1219	1321	1397
	Excess Air Operation	Minimum Capacity, kJ/hr. in 1000's	26	32	53	82	100	105
		% Excess Air	500	900	1100	1050	1160	1400

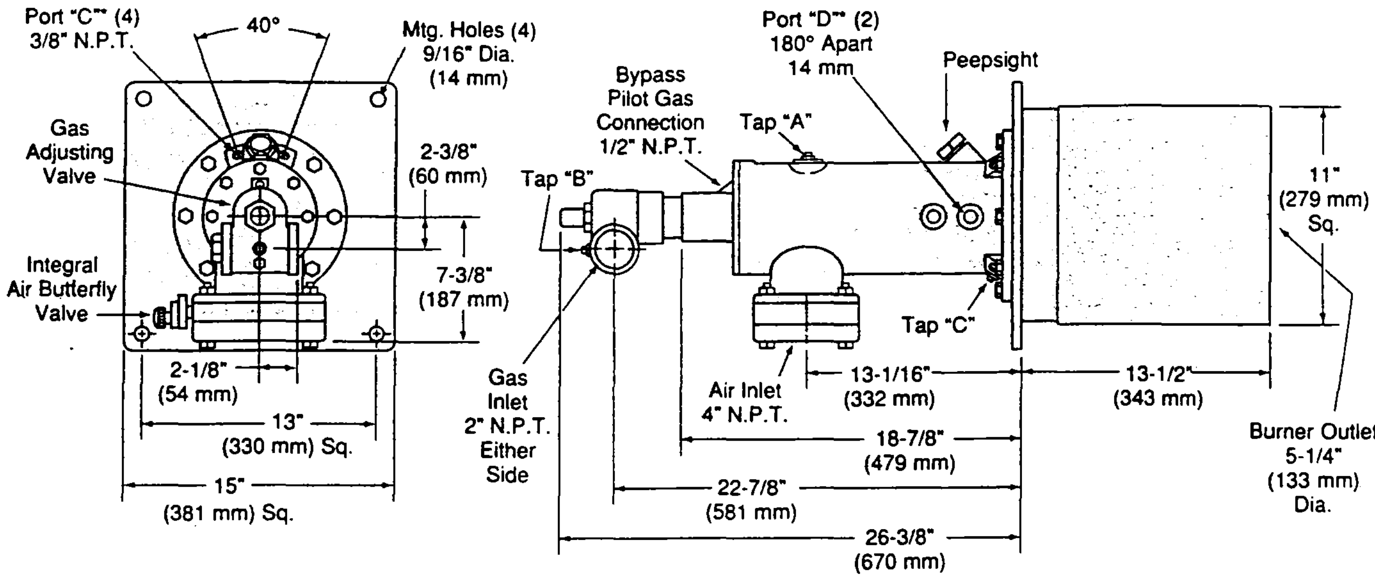
* For burner less parts group. For burner with parts group, the required gas pressure at high fire to the gas valve (not Tap "B") is 12.5" w.c. (3114 Pa.). Gas ΔP between taps "B" and "C" remains unchanged.
Size bypass pilot piping and accessories to ensure 2" w.c. (498 Pa.) at the burner pilot gas connection.

** Due to low pressure drops across the burner, use a separate metering orifice for burner set-up & adjustment.

† 100 Pa. (Pascal) = 1 mbar = 9.8 mm w.c.

ECLIPSE DATA SHEET
168 MVTA

Dimensions
Burner Assembly #102883



* NMP-S pilot with adaptor (#10208) may be connected to any of ports "C". When NMP-S pilot is used, flame rod (#13093) or U.V. scanner must be connected to the port "C" adjacent to the pilot connection. For bypass pilot, use ignition plug (#16927) in either of ports "D". Flame rod or U.V. scanner may then be connected to any of ports "C". Flame rod mounting requires a 1/4" x 3/8" bushing.

Although the block & holder assembly is illustrated as part of the burner, it must be ordered as a separate item. An alloy combustion tube may be ordered instead of a block & holder.

CAUTION: It is dangerous to use any fuel burning equipment unless it is equipped with suitable flame sensing devices and automatic fuel shut-off valves. Eclipse can supply such equipment or information on alternate sources.

Capacities
Using Natural Gas - 0.6 Sp. Gr.

English Units	On-Ratio Operation	Combustion Air Flow in 1000's SCFH	6	10	15	20	25	30
		Static Air Press. at Tap "A," "w.c.	0.35	0.9	2.1	3.8	6.0	8.5
		Air ΔP Between Taps "A" & "C," "w.c.	0.15	0.45	1.1	2.1	3.2	4.5
		Static Gas Press. at Tap "B," "w.c.	0.3	0.90	2.1	4.0	6.3	9.5
		Capacity in 1000's Btu/Hr.	600	1000	1500	2000	2500	3000
		Approx. Flame Length, Inches	20	25	32	38	44	52
	Excess Air Operation	Minimum Gas Flow, SCFH	60	90	110	140	160	190
		% Excess Air	900	1000	1260	1330	1460	1480
Metric Units*	On-Ratio Operation	Combustion Air Flow in Nm^3/hr.	161	268	402	536	670	804
		Static Air Press. at Tap "A," Pa.	87	224	523	947	1495	2117
		Air ΔP Between Taps "A" & "C," Pa.	37	112	274	523	797	1121
		Static Gas Press. at Tap "B," Pa.	75	224	523	996	1569	2367
		Capacity in 1000's kJ/hr.	633	1055	1582	2110	2637	3165
		Approx. Flame Length, mm	508	635	813	965	1118	1321
	Excess Air Operation	Minimum Capacity, kJ/hr. in 1000's	63	95	116	148	169	200
		% Excess Air	900	1000	1260	1330	1460	1480

* 100 Pa (Pascal) = 1 mbar = 9.8 mm w.c.

Due to low gas pressure drops across the burner, Eclipse recommends using a separate metering orifice for burner set-up and adjustments. See Bulletin P-15.

Size bypass pilot piping and accessories to ensure 2"w.c. (498 Pa.) at the burner pilot gas connection.

ECLIPSE COMBUSTION
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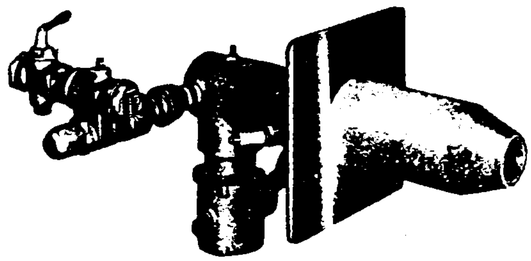
CANADA: ECLIPSE THERMAL SYSTEMS
HOLLAND: FLAMECO-ECLIPSE

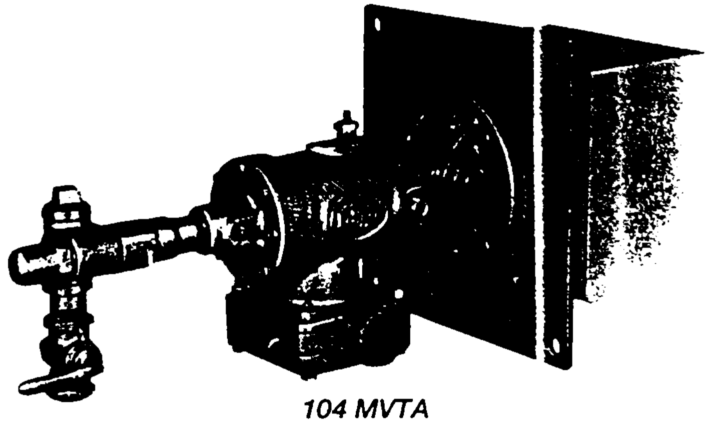
Info 210 & 215
10/91
formerly H-44-1 & -2

ECLIPSE INFORMATION GUIDE

Velocity Tempered Air Burners Series HVTA/MVTA



82 HVTA
Complete Assembly
w/Silicon Carbide Tube



104 MVTA
Complete Assembly

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ECLIPSE COMBUSTION
ROCKFORD, ILLINOIS 61103 (815) 877-3031
CANADA: ECLIPSE FUEL ENGINEERING CO.
HOLLAND: FLAMECO-ECLIPSE
ENGLAND: ECLIPSE THERMAL SYSTEMS

WARNING

The burners covered in this Guide are designed to mix fuel with air and burn the resulting mixture. All fuel burning devices are capable of producing explosions and fires when improperly applied, installed, adjusted, controlled, or maintained. This Guide will provide information for using these burners for their limited design purpose. Do not deviate from any instructions or application limits in this Guide without written advice from the Eclipse Combustion Division in Rockford, Illinois. Read this entire Guide before attempting to light burners. If you do not understand any part of the information in this Guide, contact your local Eclipse representative or Eclipse Combustion before proceeding further.

Important Notices About Safe Burner Operation

1. Store the burner inside. Exposure to the elements can damage the burner.
2. Adjustment, maintenance, and troubleshooting of the mechanical parts of this unit should be done by people with good mechanical aptitude and experience with combustion equipment.
3. Order replacement parts from Eclipse Combustion only. Any customer-supplied valves or switches should carry UL, FM , CSA, and/or CGA approval where applicable.
4. The best safety precaution is an alert and competent operator. New operators must be thoroughly instructed and demonstrate an adequate understanding of the equipment and its operation. Regular retraining must be scheduled to maintain a high degree of proficiency. The operator must have easy access to this Information Guide at all times.

1.0 Applications

HVTA and MVTA burners are versatile, nozzle-mixing gas burners suited to a wide range of applications including heat treating, kiln preheating and firing, annealing, stress-relieving, and drawing or slow cooling where oxidizing conditions are desirable. They operate dependably when firing multi-purpose furnaces, such as one operating at 1800°F for hardening and 1100°F for annealing. These burners can be used with any clean, commercially available fuel gas.

2.0 Burner Operating Parameters & Requirements

2.1 Capacities and Supply Pressures

Capacities and supply pressures are listed in the data sheets of each burner. If you do not have a data sheet for your particular burner, contact Eclipse to order it.

HVTA Burner	Data Sheet	MVTA Burner	Data Sheet
51.5	210-1	51.5	215-1
82	210-2	82	215-2
84	210-3	84	215-3
104	210-4	104	215-4
168	210-5	168	215-5
248	210-6	248	215-6
3216	210-7	3216	215-7

2.2 Burner Environment

Ambient temperature limits are dictated by monitoring and control equipment such as flame scanners, automatic fuel shutoff valves and electrical wiring.

Protect burners from the weather.

Contaminated combustion air might corrode or plug the blower or burner's internal passages. Eclipse strongly recommends the use of a combustion air filter suitable for the operating conditions.

To insure a fresh supply of combustion air, provide access to outdoor air. Allow at least one square inch of opening for each 4,000 Btu/hr. of burner firing rate.

Provide access to the burners for inspection, maintenance and removal.

3.0 Control System Requirements

3.1 **Control Methods**

There are three commonly used control systems: excess air, proportioning or a combination of the two. Components for these three systems are illustrated in Figure 4. See Section 6.0 for adjustment procedures of these systems.

3.2 **Piloting**

The spark of the ignition plug used for bypass piloting may energize a U.V. scanner system even when no pilot flame is present. To prevent this, control sequencing must turn off the spark before main gas shut-off valves are energized.

3.3 **Flame Supervision**

Flame monitoring may be by flame rod or ultraviolet flame sensing device (U.V. scanner).

On burners with self-piloting—also known as bypass pilots—Eclipse strongly recommends that main and pilot gas lines be equipped with approved automatic shutoff valves interlocked to close in the event of flame or limit failure.

Flame sensing equipment should be UL, FM and/or CSA approved.

Refer to Eclipse Information Guide P-30 for specific details on the installation and use of flame monitoring equipment.

WARNING

Failure to use suitable flame sensing devices and automatic fuel shutoff valves can cause explosions and fires.

3.4 **Fuel Valve Trains**

Gas must be supplied to the burner inlet through a valve train which complies with NFPA standards and all applicable local codes. Eclipse offers prepiped FM and IRI type gas valve trains. IRI-type trains meet or exceed NFPA standards. Each valve train can be suppied with or without a gas regulator.

3.5 **Limit Controls**

Limit controls and safety equipment should comply with current NFPA Standard 86 and all applicable local codes and/or standards. NFPA standards are available from:

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

.0 Burner Installation

4.1 **Burner Inspection**

Make a thorough inspection when uncrating and before installing the burner. If any parts appear broken, bent, or damaged, contact your Eclipse representative or the Eclipse factory before installing the burner.

4.2 **Burner Mounting**

Install burners with blocks & holders as suggested in Eclipse P-5 Installation Guide. See Figure 1 for installing silicon carbide nozzles or alloy combustion tubes.

Bolt the burners to the furnace shell through the holes in the mounting flange. Install a suitable ceramic fiber gasket between the flange and the furnace shell.

The burner mounting flange will support only the weight of the burner body and supplied components. Burner supply piping must be supported adequately and independently.

4.3 **Burner Piping**

Gas piping must comply with American National Standard entitled "National Fuel Gas Code"* (NFPA No. 54 or ANSI Z223.1), or must be acceptable to the authority having jurisdiction.

For optimum results, size combustion air piping for 40 ft./second velocity and natural gas piping for 70 ft./ second velocity at maximum flow.

4.4 **General Wiring Suggestions**

Electrical wiring must comply with the National Electric Code*, (NFPA Std. 70 or ANSI-CI 1981), or must be acceptable to the authority having jurisdiction.

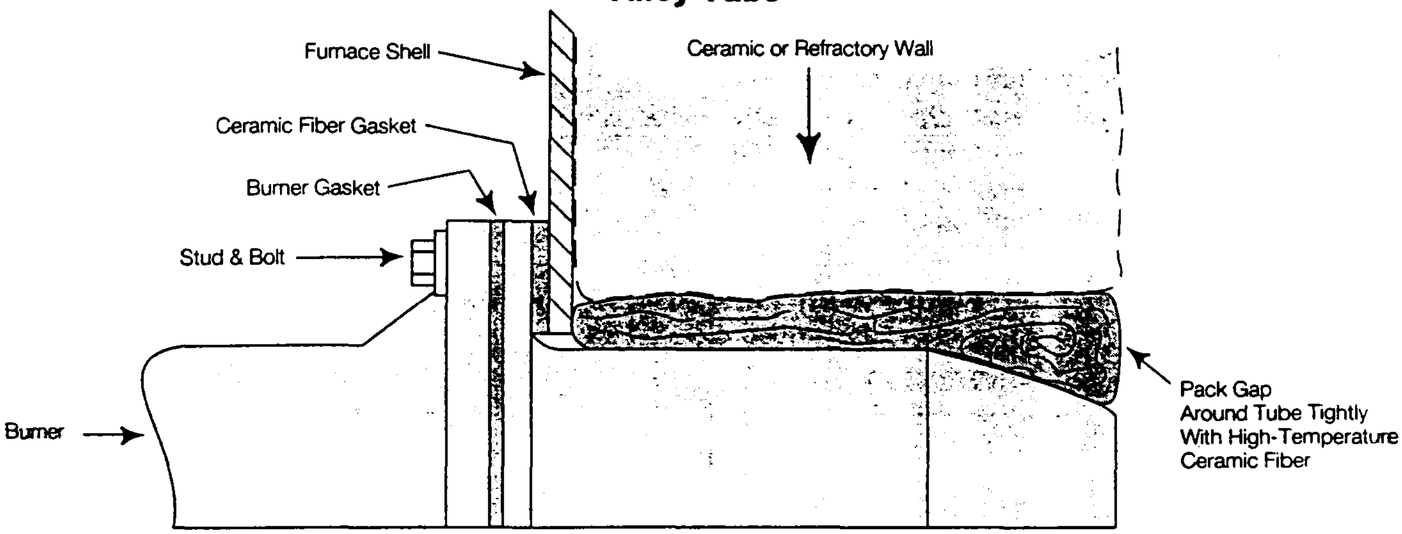
*Available from:

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

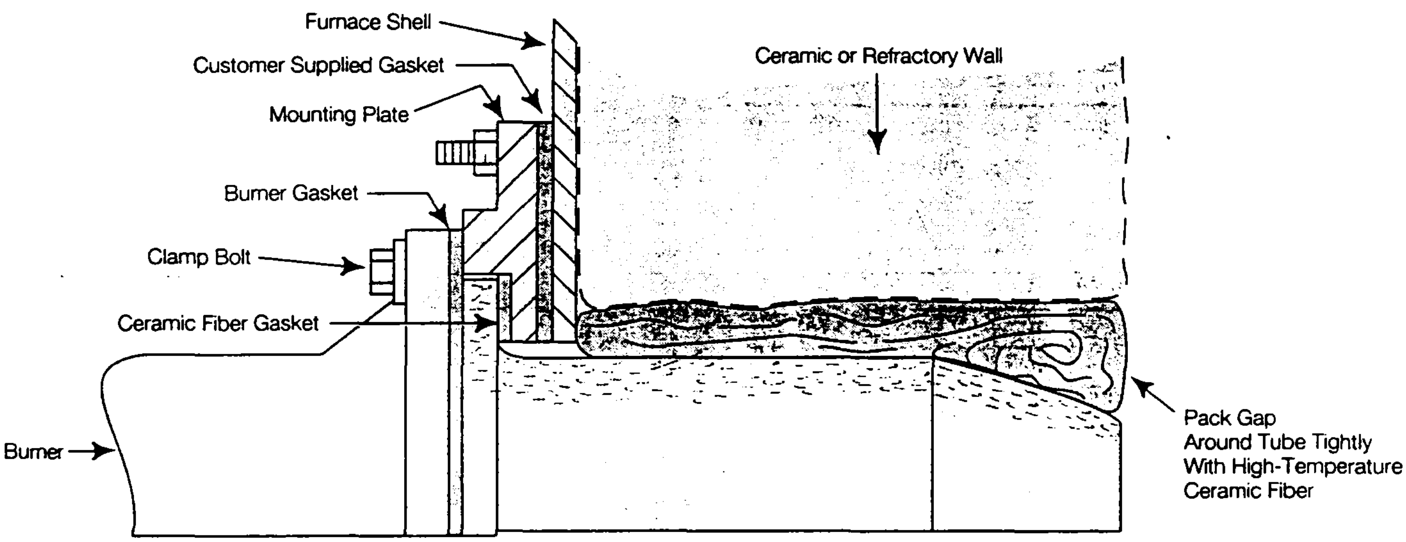
American National Standard Institute
1430 Broadway
New York, New York 10018

Figure 1–Alloy & Silicon Carbide Tube Installation

Alloy Tube



Silicon Carbide Tube



Note: Tighten bolts just enough to compress gaskets. Overtightening may break the silicon carbide tube flange.

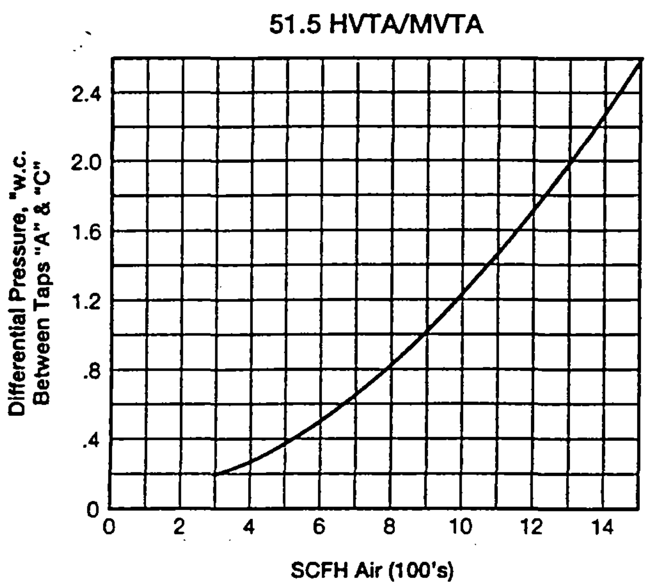
5.0 Air and Gas Flow Measurement

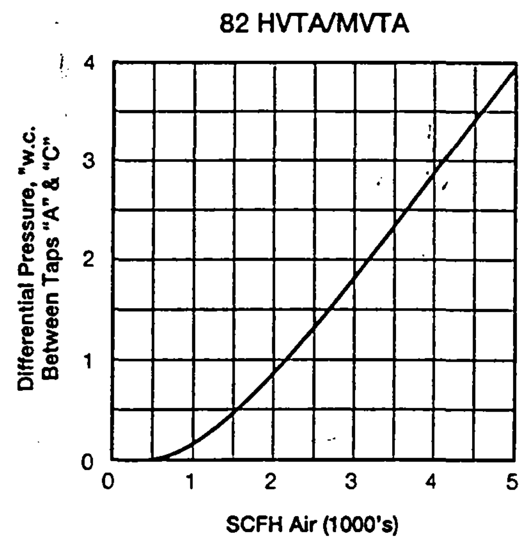
5.1 Air flow through the burner can be determined by measuring the differential pressure across taps "A" and "C" of the burner. The graphs in Figure 2 relate the measured pressure drop to air flow.

5.2 Gas flow through the 82 HVTA/MVTA burners can be determined by measuring the differential pressure across taps "B" and "C". Figure 3 relates the measured pressure drop to gas flow.

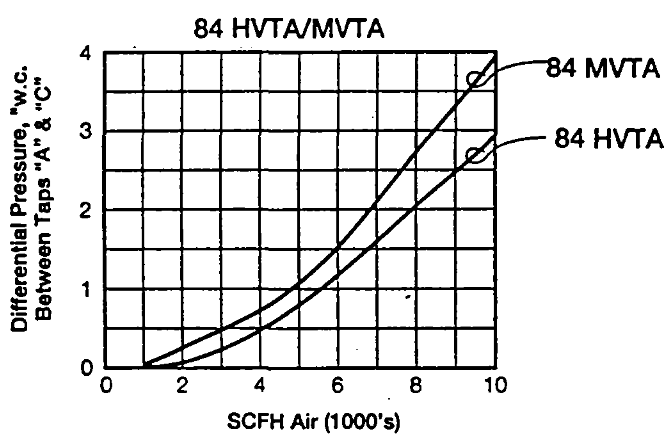
5.3 Gas pressure drops for 51.5 and 84 through 3216 HVTA/MVTA burners are too low to use as accurate flow estimates. Use separate metering orifices in the gas lines. **When using metering orifices, provide a straight run at least ten pipe diameters upstream and at least five diameters downstream of each orifice. Failure to comply will cause inaccurate meter readings.**

Figure 2-Air Flow Adjustment Data

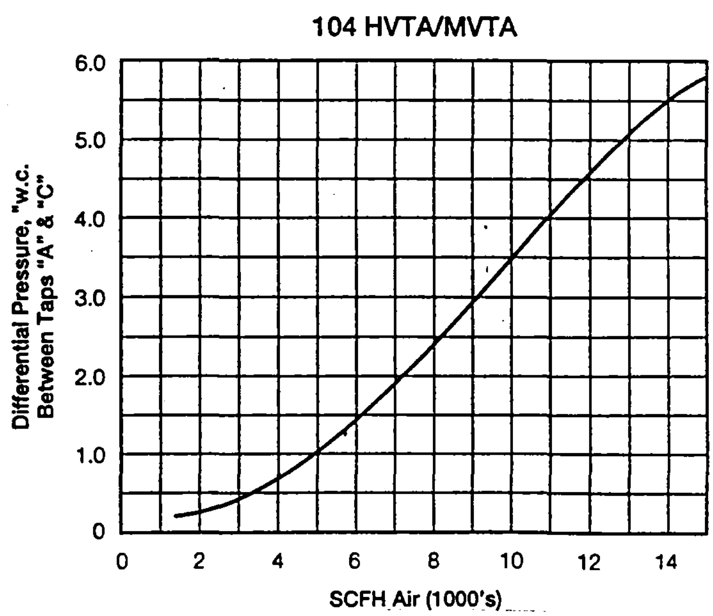





```
VAC10       0.24 mmBTU/HR
Hi Fire     1.4" wc (10% Excess)
Lo Fire     0.2" wc
```



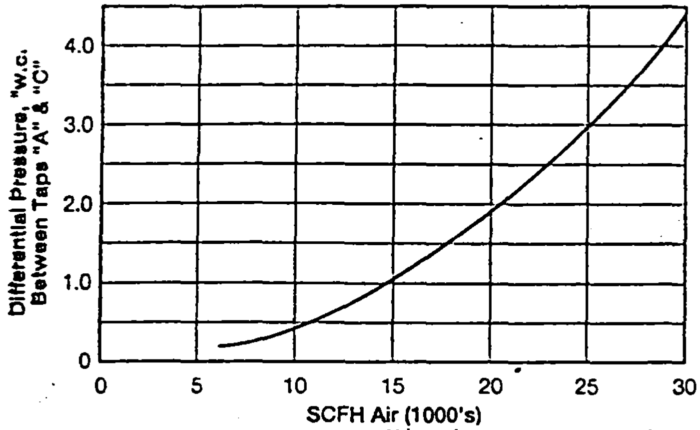

```
VAC25       0.6 mmBTU/HR
Hi Fire     1.4" wc (10% Excess)
Lo Fire     0.2" wc
```




```
VAC50       1.2 mmBTU/HR
Hi Fire     5.2" wc (10% Excess)
Lo Fire     0.2" wc
```

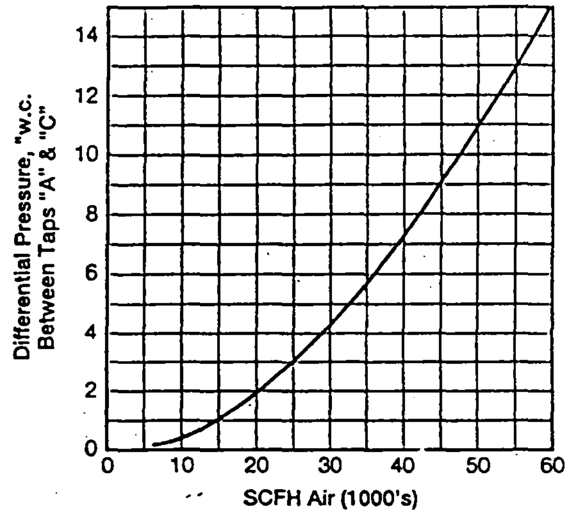
Figure 2-Air Flow Adjustment Data (continued)

168 HVTA/MVTA

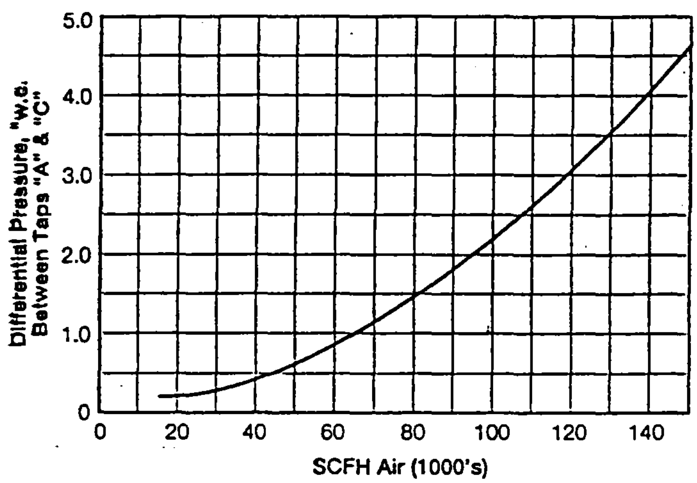


		Hi Fire (10% Excess)	Lo Fire
VAC75	1.8mmBTU/HR	2.8" wc	0.2" wc
VAC100	2.4mmBTU/HR	3.3" wc	0.2" wc
VAC150	3.6mmBTU/HR	7.3" wc	0.2" wc

248 HVTA/MVTA



3216 HVTA



3216 MVTA

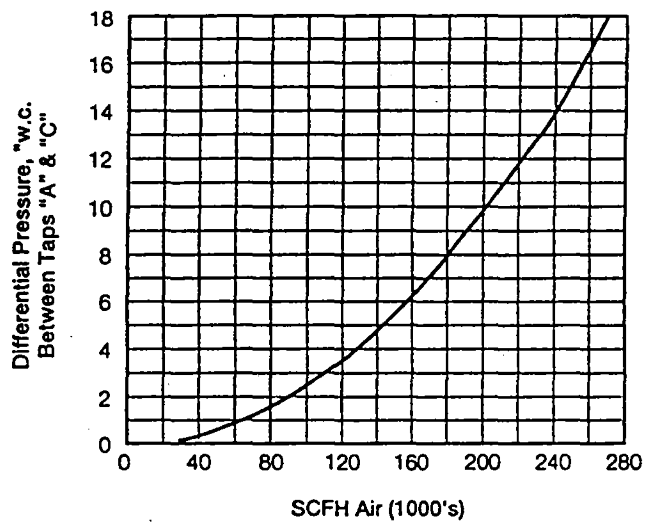
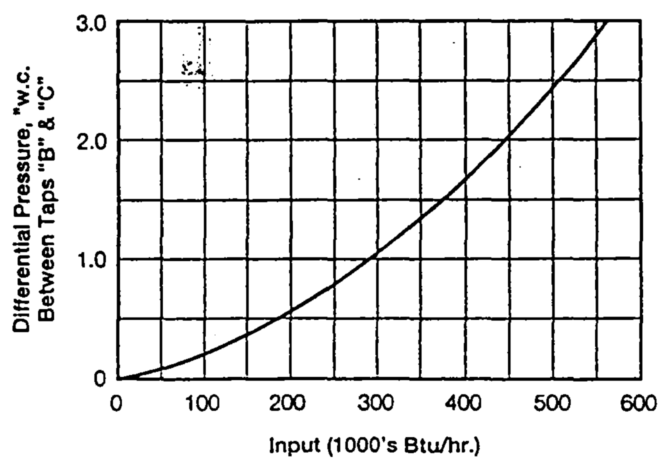


Figure 3-Natural Gas Flow Adjustment Data

82 HVTA/MVTA



6.0 Initial Start-Up & Adjustment

6.1 Initial Settings

Close all manual and automatic gas valves including the gas balancing valves, pilot adjusting cocks, and pilot shutoff cocks.

Close the air balancing valves.

6.2 Adjust Control Valve Linkages

Air Control Valve (if used): Adjust the linkage of the air control valve so that the butterfly opens 75% (100% for reduced port butterfly valves) when the operator moves to the high fire limit of its stroke.

Gas Control Valve (if used): Adjust the linkage of the gas control valve so that the butterfly will move from about 20% open at the low fire limit of its stroke to 75% open (100% for reduced port butterfly valves) at the high fire limit.

6.3 Start Blower

Start the combustion air blower. Visually confirm that the fan or impeller is rotating in the correct direction. If rotation is wrong, have a qualified electrician change the wiring to the blower motor.

6.4 Adjust Air Flow

Proportioning Systems:

Drive air control valve to high fire.

Measuring air flow as described in section 5.0, gradually open each air balancing valve until the desired high fire air flow is reached. When all balancing valves in a zone have been adjusted, recheck the air flow measurements.

Adjust the linkage of the air control valve to produce the desired low fire air flow. Cycle the air control valve several times, checking high fire and low fire air flow measurements.

Drive air control valve to low fire.

Excess Air Systems:

Measuring air flow as described in section 5.0, gradually open each air balancing valve until the desired high fire air flow is reached. When all balancing valves in a zone have been adjusted, recheck the air flow measurements.

Proportioning/Excess Air Systems:

Switch control system to proportioning operation. This should lock the zone gas control valve (3) in the high fire position and release the zone air control valve (1) to the temperature controller.

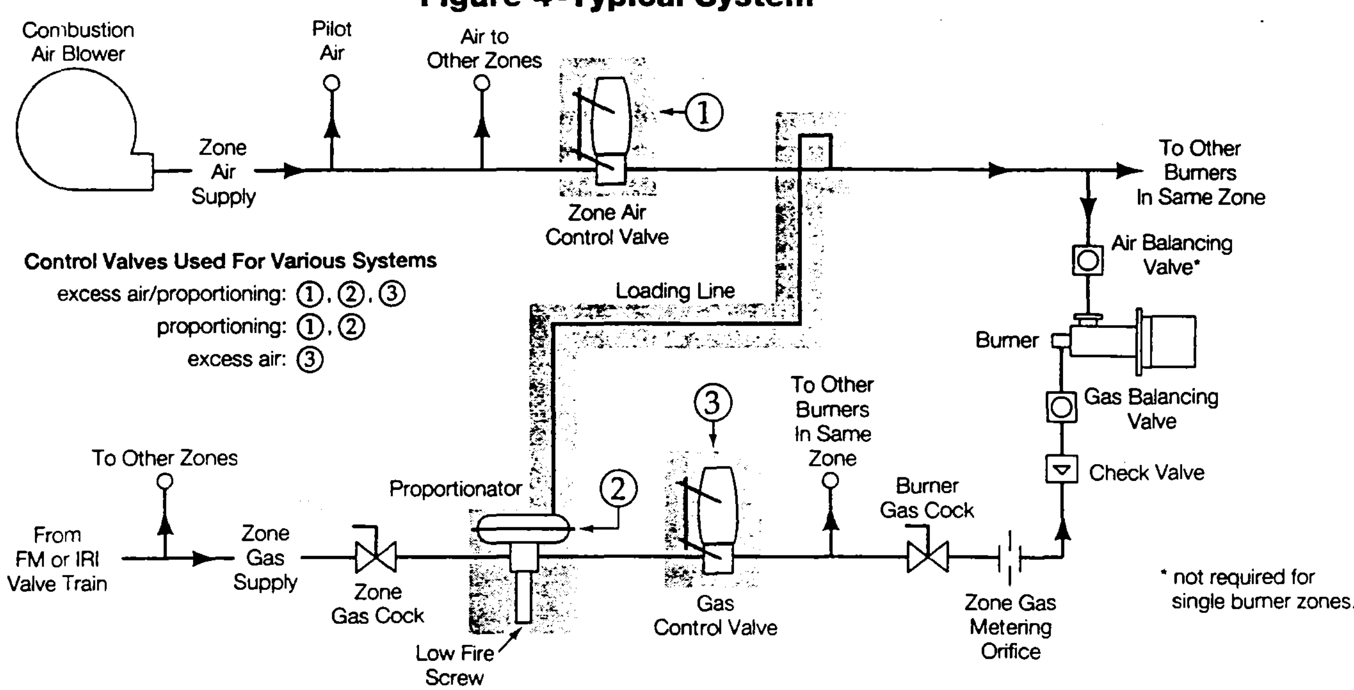
Drive air control valve to high fire.

Measuring air flow as described in section 5.0, gradually open each air balancing valve until the desired high fire air flow is reached. When all balancing valves in a zone have been adjusted, recheck air flows.

Adjust the linkage of the air control valve to produce the desired low fire air flow. Cycle the air control valve several times, checking high fire and low fire air flows.

Drive air control valve to low fire.

Figure 4–Typical System



6.5 Light Pilots

Energize the ignition transformer and pilot solenoid.

Ignite and adjust blast type pilots according to the instructions furnished by the manufacturer. For bypass piloting, open the pilot shutoff cock and gradually open the pilot adjusting valve until the pilot lights. Close the pilot shutoff cock and reopen several times to make sure the pilot ignites reliably. Light all pilots in the zone.

6.6 Adjust Gas Flow

Proportioning Systems:

Verify that the gas pressure entering the proportionator equals the maximum air loading pressure to the proportionator, plus the expected high fire gas pressure drop across the proportionator. If gas pressure cannot be raised to that level, a bleed fitting may be required.

Open all gas valves upstream of the gas balancing valves.

Measuring gas flow as described in section 5.0, gradually open each gas balancing valve until the corresponding burner lights. Do not open the valves past the point required for burner ignition.

Drive the air control valve to high fire. Check to be sure the burners remain lit.

Adjust the gas balancing valves to provide the desired high fire gas flow.

Drive the air control valve to low fire. Adjust the proportionator spring to produce the desired low fire gas flow.

Cycle the air control valve several times to be sure the burners are properly adjusted at all firing rates.

Excess Air Systems:

Open all gas valves upstream of the gas balancing valves.

Drive the gas control valve to high fire.

Measuring gas flow as described in section 5.0, gradually open one gas balancing valve until the corresponding burner lights, then continue opening the valve until the desired high fire gas flow is achieved. Repeat for the remaining burners.

On systems with multiple burners fed from a single motor-driven gas control valve, burners already lit may go lean as succeeding burners are lit and adjusted. Re-check and readjust lit burners as you proceed.

Drive the gas control valve to low fire. Check to be sure that all burners remain lit. Measure low fire gas flows as discussed in section 5.0 of this Guide. If necessary, readjust the linkage of the gas control valve to produce the desired low fire gas flow.

Cycle the gas control valve several times to be sure the burners are properly adjusted at all firing rates.

Proportioning/Excess Air Systems:

Verify that the gas pressure entering the proportionator equals the maximum air loading pressure to the proportionator, plus the expected high fire gas pressure drop across the proportionator. If gas pressure cannot be raised to that level, a bleed fitting may be required.

Open all gas valves upstream of the gas balancing valves.

Measuring gas flow as described in section 5.0, gradually open each gas balancing valve until the corresponding burner lights. Do not open the valves past the point required for burner ignition.

Drive the air control valve to high fire. Check to be sure the burners remain lit.

Adjust the gas balancing valves to provide the desired high fire gas flow.

Drive the air control valve to low fire. Adjust the proportionator spring to produce the desired low fire gas flow.

Cycle the air control valve several times to be sure the burners are properly adjusted at all firing rates.

Drive the air control valve to high fire.

Switch the control system over to excess air operation. This should lock the zone air control valve (1) in the high fire position and release the zone gas control valve (3) to the temperature controller.

Drive the gas control valve to low fire. Check to be sure that all burners remain lit. Measure low fire gas flows as discussed in section 5.0. If necessary, readjust the gas control valve linkage for the desired low fire gas flow.

Cycle the gas control valve several times to be sure the burners are properly adjusted at all firing rates.

7.0 Trouble-Shooting

CAUTION

Trouble-shooting of electrical circuits should be done by qualified plant electricians, technicians, or engineers experienced in all facets of this type of combustion equipment.

PROBLEM	POSSIBLE CAUSE
Pilot fails to light.	1. On initial start-up, gas line may be filled with air. Repeat ignition trial several times to purge. 2. Check ignition transformer or pilot solenoid to see that they are functioning properly. Clean and gap spark electrode. Make sure spark electrode is properly grounded. Replace if necessary. 3. Pilot solenoid valve may not be opening. Faulty electrical circuits or excessive gas inlet pressure can prevent pilot solenoid valves from opening. 4. Pilot may be out of adjustment. 5. Insufficient gas pressure into or out of pilot regulator.
Pilot lights, but main gas valve does not open.	1. Flame monitoring device may be dirty or improperly intsalled.
Main gas valve opens, but burner fails to light or goes out as it cycles to high fire.	1. Air in the gas line prevent the burner(s) from lighting on initial startup. Several trials for ignition may be necessary before gas line is purged of air. 2. System out of adjustment. Section 6.0 details respective system adjustments.
Main flame is too long and yellow on high fire.	1. Gas flow is too high. Gas balancing valve is open too far.
Main flame is too short on high fire.	1. Gas flow is too low. Gas balancing valve is closed too far.
Low fire flame is too long, soft or yellow.	1. Too much gas flow. Proportionator spring is screwed in too far. 2. Insufficient air flow due to dirty blower filter or impeller.
Low fire flame is weak or unstable.	1. Insufficient gas flow. Proportionator spring is not screwed out far enough.
Burner behaves erratically, does not respond to adjustment.	1. Burner internals loose, dirty or burned out. If this appears to be the problem, contact your Eclipse representative or the Eclipse factory for service. 2. Proportionator has broken diaphragm or dirty valve.

8.0 Maintenance

8.1 A sound maintenance program, carried out by qualified individuals, will greatly increase equipment reliability and productivity. Frequeny of maintenance checks should reflect the duty cycle of the heating equipment and conditions such as dirt and temperature. Any maintenance program should include at least the following steps:

1. Check the burner's high and low fire air and gas settings.
2. Examine and, if necessary, clean or replace any gas or air filter elements used.
3. Check all piping connections for leaks.
4. Check the ability of the flame supervision system to function properly by simulating system failures:
   a. Simulate burner flameout by manually shutting off the gas.
   b. Trip out pressure switches and other limit interlocks.
   c. Try to light the burner before the purge and other timers have finished their cycles. If simulated limit or flame failures do not shut down the fuel system with a short period of time, immediately take the equipment out of service and correct the problem.
5. Oil the linkage swivels of any electrically or pneumatically controlled valve.

8.2 **Ignition Plug and Flame Rod Replacement**
Ignition plugs and flame rods wear out over long periods of normal burner operation. Eclipse recomments that the user keep at least one of each in stock at all times to prevent nuisance shutdowns.

To determine flow from a measured pressure drop: Find the pressure on the left-hand side of the chart; read across to the appropriate curve; read down to the uncorrected flow. *Multiply* this flow by the correction factors that apply.

Example: You measured 8" w.c. air pressure differential. Inlet pressure to the orifice is 3 psig, temperature is 120° F, and altitude is 5000 ft. What is the flow?

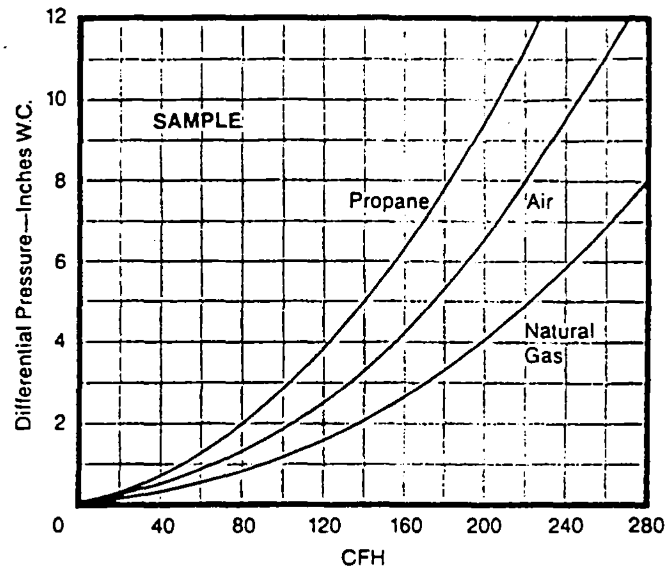
Find 8" w.c. on the left-hand side of the sample chart; read across to the air curve, then down to an uncorrected flow of 220 cfh. Multiply 220 cfh by .94 (temp. correction) and by .98 (inlet press. / elevation correction) to get a corrected flow of 203 scfh.

To determine the pressure drop required for a desired flow: *Divide* the flow by the correction factors. Locate this corrected flow at the bottom of the graph; read up to the appropriate curve, then read left to the differential pressure.

Example: You want to set natural gas flow to a burner at 160 scfh. Gas temperature is 90° F, inlet pressure to the orifice is 5 psig, and altitude is 500 ft. What orifice differential is required for these conditions?

Divide 160 scfh by .97 (temp. correction) and by 1.11 (inlet press. / elevation correction) to get an actual flow of 149 cfh. Locate 149 cfh at the bottom of the sample chart; read up to the natural gas curve, then read left to a pressure drop of 2.3" w.c.

For gases other than natural gas, air, or propane, follow the procedures described, but use the air curve and include a specific gravity correction factor along with the factors for temperature, pressure, and altitude.



TEMPERATURE CORRECTION FACTORS

Temp °F	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
Factor	1.01	1.00	.99	.98	.97	.96	.95	.94	.94	.93	.92	.92	.91	.90	.89	.88

INLET PRESS. AND ALTITUDE CORRECTION FACTORS

	Orifice Inlet Pressure, PSIG															
Altitude	.5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sea Level	.98	1.00	1.03	1.06	1.09	1.12	1.15	1.18	1.20	1.23	1.25	1.28	1.30	1.33	1.35	1.37
500′	.97	.99	1.02	1.05	1.08	1.11	1.14	1.17	1.19	1.22	1.25	1.27	1.30	1.32	1.34	1.37
1000′	.97	.98	1.01	1.05	1.08	1.10	1.13	1.16	1.19	1.21	1.24	1.27	1.29	1.31	1.34	1.36
2000′	.95	.97	1.00	1.03	1.06	1.09	1.12	1.15	1.17	1.20	1.23	1.25	1.28	1.30	1.33	1.35
3000′	.93	.95	.98	1.01	1.04	1.07	1.10	1.13	1.16	1.19	1.21	1.24	1.26	1.29	1.31	1.34
4000′	.92	.93	.97	1.00	1.03	1.06	1.09	1.12	1.15	1.17	1.20	1.23	1.25	1.28	1.30	1.33
5000′	.90	.92	.95	.98	1.02	1.05	1.08	1.11	1.13	1.16	1.19	1.22	1.24	1.27	1.29	1.32
6000′	.88	.90	.94	.97	1.00	1.03	1.06	1.09	1.12	1.15	1.18	1.20	1.23	1.26	1.28	1.31

SPECIFIC GRAVITY CORRECTION FACTORS (Use Only With Air Curve)

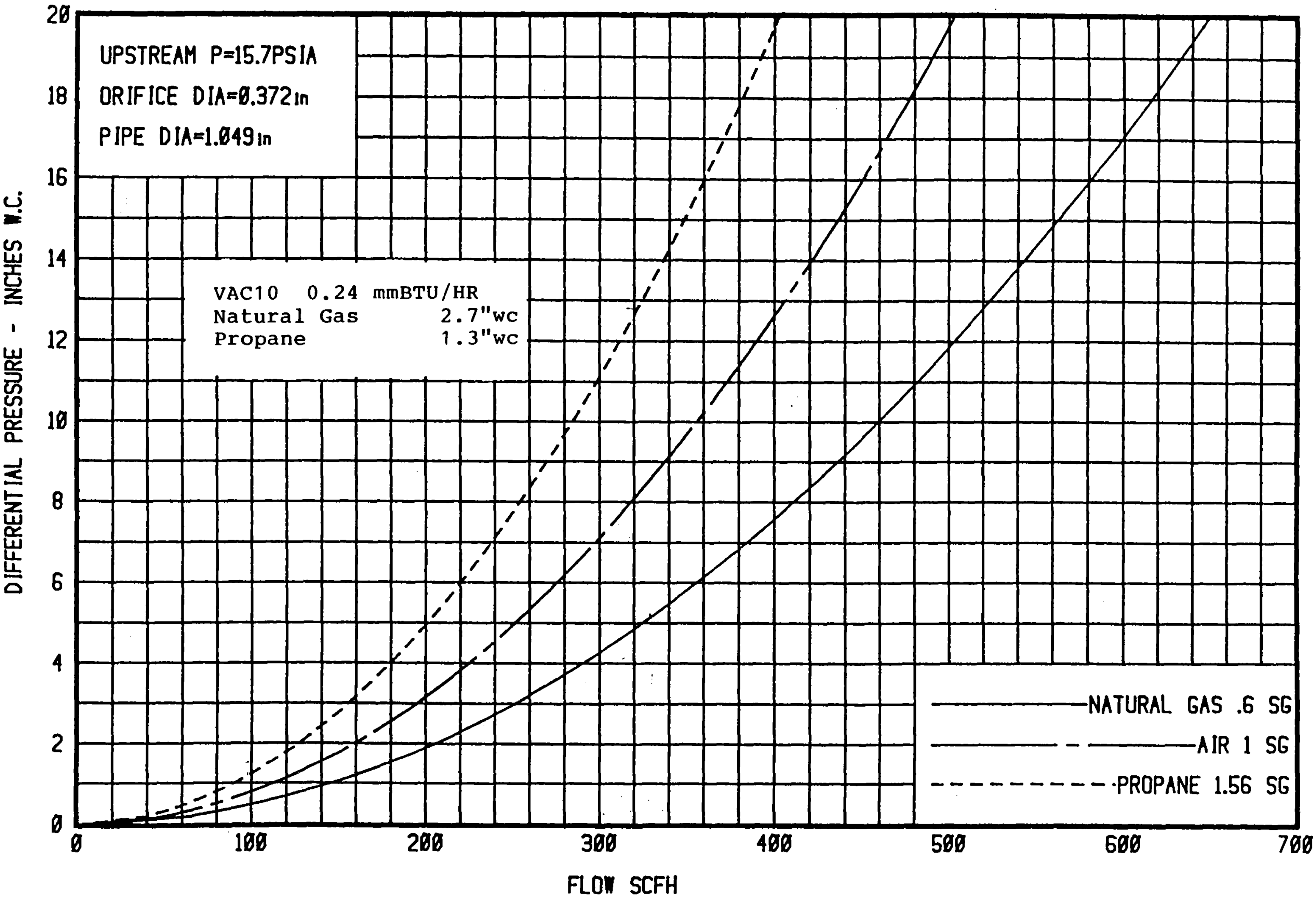
Specific Gravity	.40	.50	.60	.65	.70	.80	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
Factor	1.58	1.41	1.29	1.20	1.12	1.05	1.00	.95	.91	.88	.85	.82	.79	.77	.75	.73	.71

Eclipse

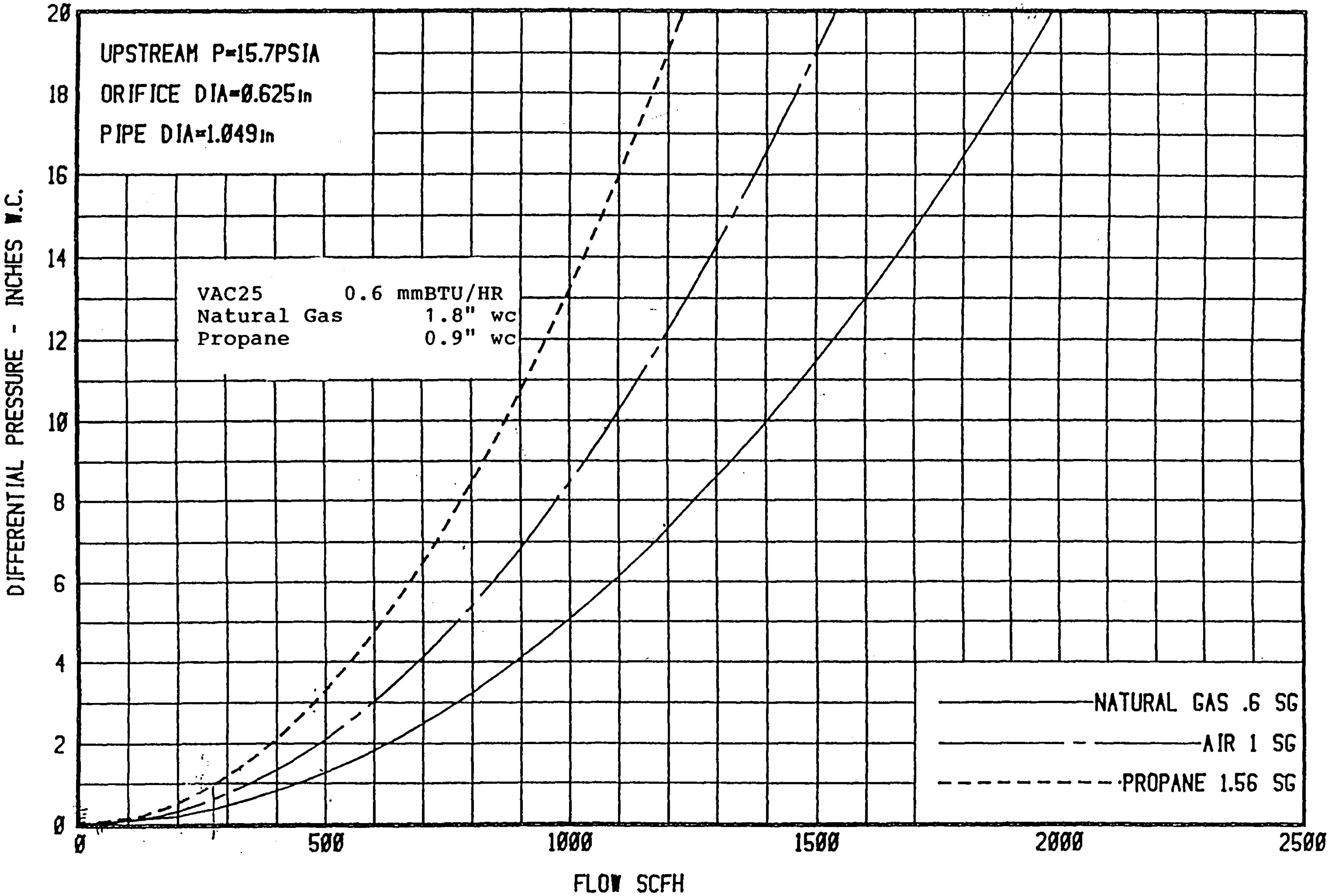
ECLIPSE COMBUSTION
A DIVISION OF ECLIPSE, INC.
ROCKFORD, ILLINOIS 61103 (815) 877-3031
IN CANADA: ECLIPSE FUEL ENGINEERING CO. OF CANADA LTD DON MILLS, ONTARIO

Litho in U.S.A.

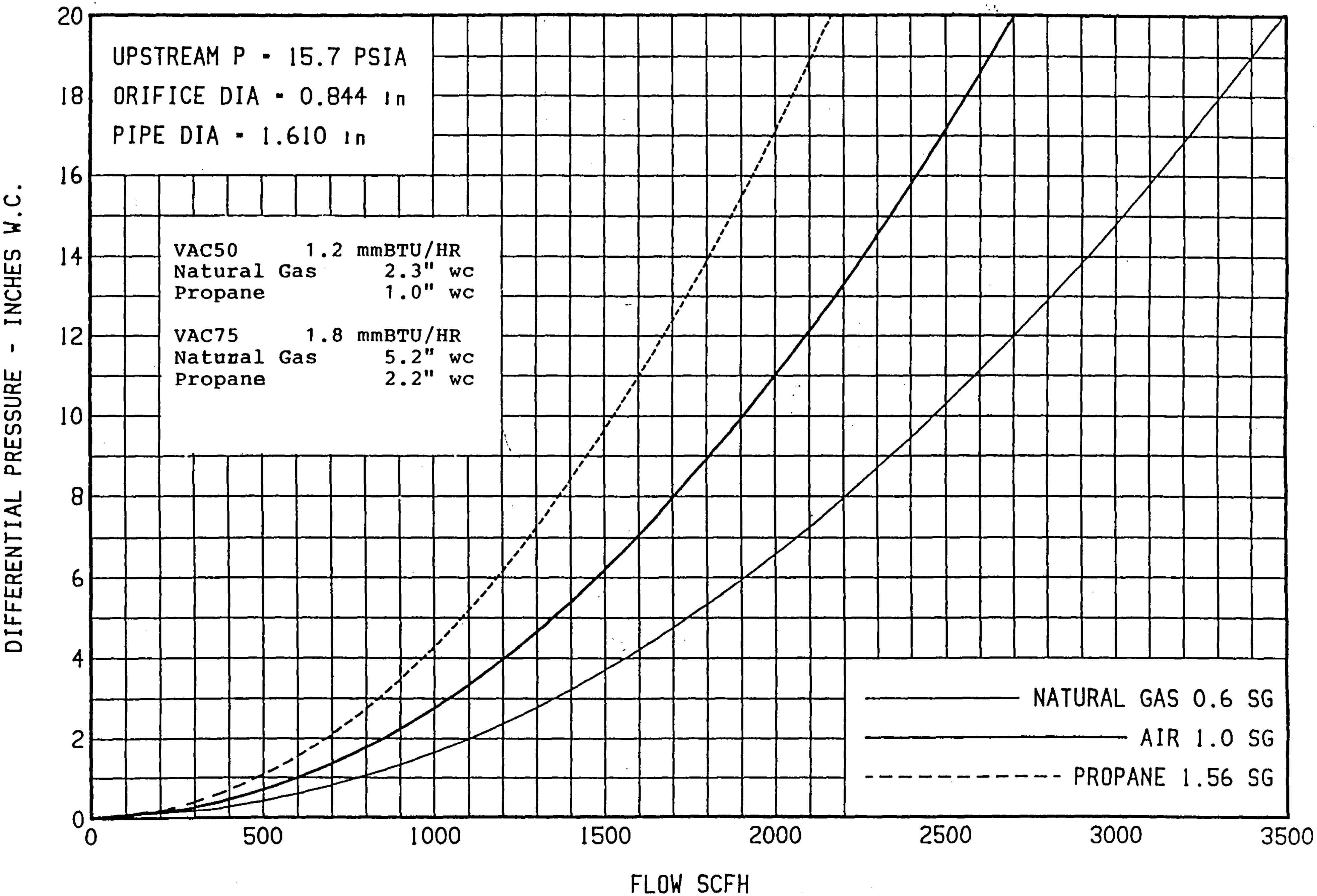
FLOW CURVE FUR 4-2 FOM

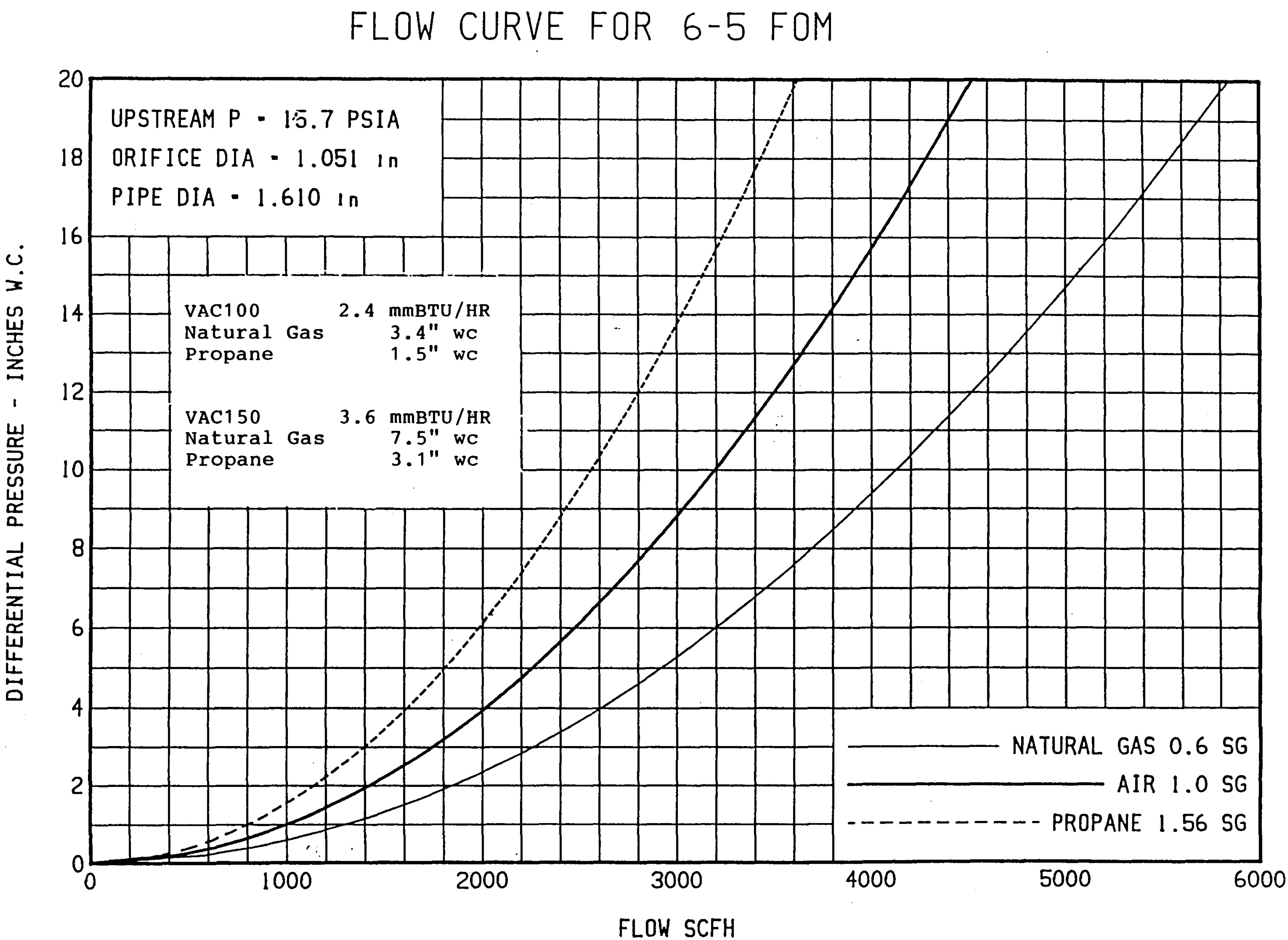


FLOW CURVE FOR 4-5 FOM



FLOW CURVE FOR 6-4 FOM



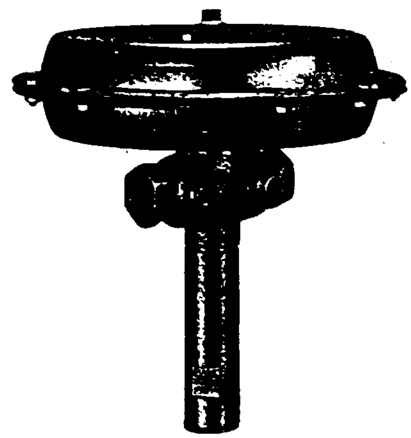

FLOW CURVE FOR 6-5 FOM
UPSTREAM P - 15.7 PSIA
ORIFICE DIA - 1.051 in
PIPE DIA - 1.610 in
VAC100 2.4 mmBTU/HR
Natural Gas 3.4" wc
Propane 1.5" wc
VAC150 3.6 mmBTU/HR
Natural Gas 7.5" wc
Propane 3.1" wc
NATURAL GAS 0.6 SG
AIR 1.0 SG
PROPANE 1.56 SG
DIFFERENTIAL PRESSURE - INCHES W.C.
FLOW SCFH
0
2
4
6
8
10
12
14
16
18
20
0
1000
2000
3000
4000
5000
6000

ECLIPSE INFORMATION GUIDE
ADJUSTABLE BIAS PROPORTIONATOR VALVES
SERIES ABP

NOTE

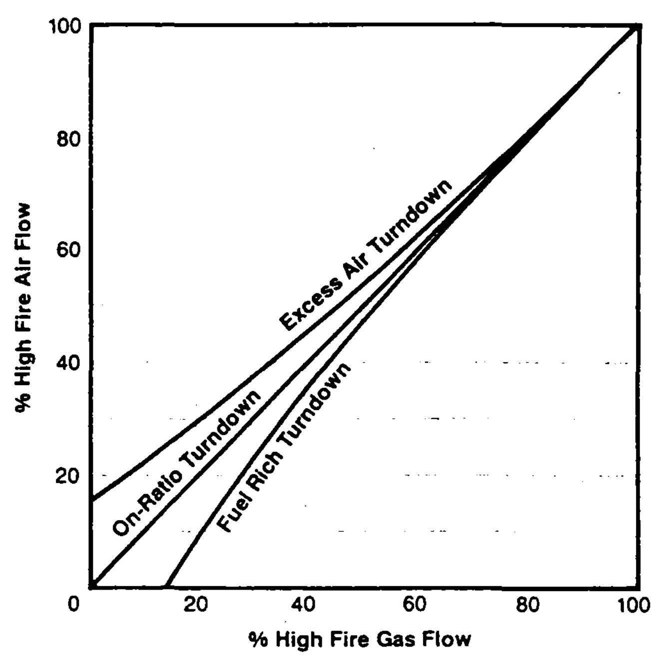
1. These valves must be mounted with the adjusting tower pointing straight down. Be sure to allow at least 6" clearance below the tower for bias adjustment.

2. These valves are designed for use as control valves only. They must not be used as fuel shut-off valves.



Eclipse Adjustable Bias Proportionators (ABP) are designed to vary gas flow to burners in proportion to changes in combustion air flow. As shown in Figure 1, the ABP can be adjusted to hold a constant air/gas ratio during turndown, or to shift the air/gas ratio toward excess air or excess gas operation.

FIGURE 1 - TYPICAL BIASING CURVES (ON-RATIO HIGH FIRE)



ECLIPSE COMBUSTION

1.0 SPECIFICATIONS AND OPERATING LIMITS

Maximum Inlet Pressure: 2.5 psi.

Maximum Differential Pressure Between Inlet and Loading Line: 2.0 psi.

Maximum Ambient Temperature: 140F.

Compatible Gases: Air, natural gas, propane vapor, butane vapor. Contact factory to determine compatibility of other gases.

CAUTION: Exceeding these limits may damage the valve.

	NG	Propane
VAC10	2.0"	2.0"
VAC25	2.0"	2.0"
VAC50	7.0"	3.0"
VAC75	2.0"	2.0"
VAC100	3.0"	2.0"
VAC150	5.5"	2.5"

FIGURE 2 - CAPACITIES, SCFH*

		ABP Gas Inlet Pressure Minus Loading Line Pressure							
Catalog Number	Pipe Size	Minimum 2"W.C.	4"W.C.	6"W.C.	8"W.C.	14"W.C. (0.5 psi)	28"W.C. (1.0 psi)	42"W.C. (1.5 psi)	Maximum 56"W.C. (2.0 psi)
104 ABP	1"	650	920	1130	1300	1720	2430	2980	3440
106 ABP	1-1/2"	2190	3100	3800	4380	5800	8200	10000	11600
108 ABP	2"	3890	5500	6740	7780	10300	14600	17800	20600
112 ABP	3"	7850	11100	13600	15700	20800	29400	36000	41500

*Capacities listed are for natural gas at .65 sp. gr. For other gases, multiply capacities by these factors: Butane, .548; propane, .628; air, .775.

2.0 SYSTEM REQUIREMENTS AND OPERATION

2.1 THE ABP is normally installed in the main gas line to one or more burners, as shown in Figure 3. The top chamber of the ABP is connected through a loading line to the combustion air manifold downstream of the main air control valve. Referring to Figure 4, the ABP valve stem moves downward to increase gas flow, upward to decrease gas flow. Valve stem weight, loading line pressure on the diaphragm, and gas inlet pressure on the valve disc all tend to open the valve. These forces are opposed by spring pressure and by gas outlet pressure applied to the diaphragm through the connecting passage.

At high fire, the valve will be almost fully open. As combustion air flow is reduced, loading line pressure drops and the valve begins to close. If the spring pressure exactly balances valve stem weight and inlet pressure, the valve will maintain the high fire air/gas ratio during turndown. If, however, the adjusting screw has been turned clockwise to increase spring pressure, the air/gas ratio will become increasingly lean as loading line pressure drops. Turning the screw counterclockwise from the balanced point will decrease spring pressure, producing fuel rich turndown.

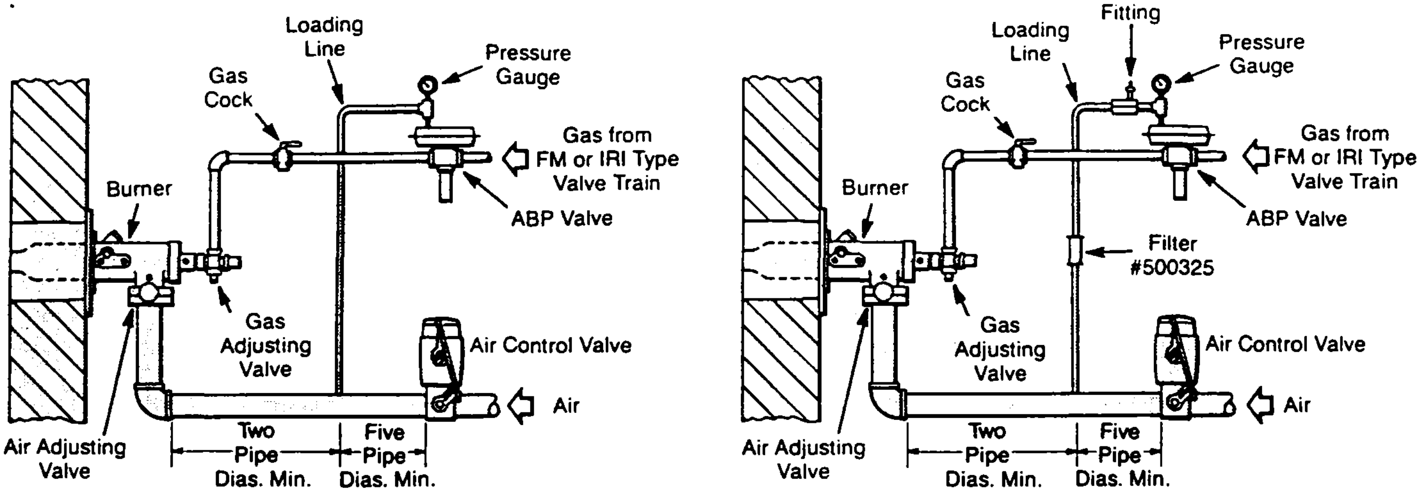
During system start-up with low fire loading line pressure but no gas inlet pressure, the ABP is closed. When the safety shut-off valves open upstream of the ABP, the valve gradually opens to the low fire position, initially providing a very lean mixture. This action prevents the fuel surge common to conventional proportionator valves which are fully open at system start-up.

During operation, loading line pressure will be approximately equal to ABP outlet pressure. **For good system control, the drop through the ABP body should never be less than 2" w.c. or greater than 56" w.c.**

2.2 The 104 and 106 ABP are furnished with two adusting springs. A red spring is installed at the factory and is suitable for most applications. Under certain conditions, however, the alternate yellow spring will give the valve better low fire flow characteristics. See Figure 5 to determine which spring will be required for individual applications.

108 and 112 ABP's are furnished with a single adjusting spring which gives the required biasing characteristics under all normal operating conditions.

FIGURE 3 - TYPICAL APPLICATIONS



Gas pressure available at ABP outlet is greater than loading line pressure.

Gas pressure available at ABP outlet is less than loading line pressure.

FIGURE 4 - ABP CROSS SECTION

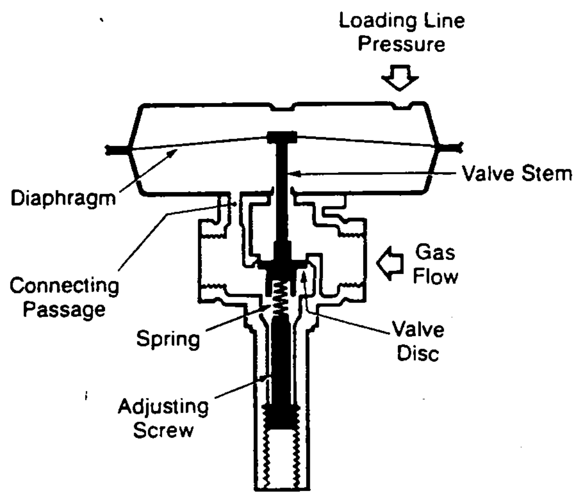


FIGURE 5 - 104 & 106 ABP SPRING SELECTION

DIRECTIONS:
1. Locate low fire combustion air loading pressure on vertical axis.
2. Move right to intersection with ABP inlet gas pressure.
3. Choose spring according to the area of the graph in which the intersection falls: Upper portion, yellow spring for both valves; Middle section, red spring for 104 ABP, yellow spring for 106 ABP; Lower section, red spring for both valves.

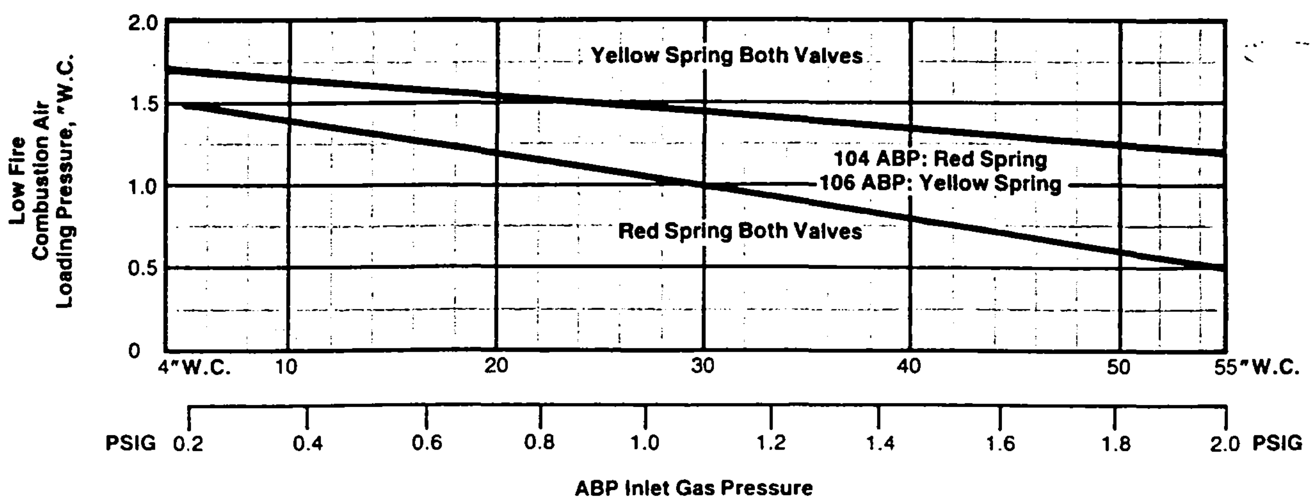
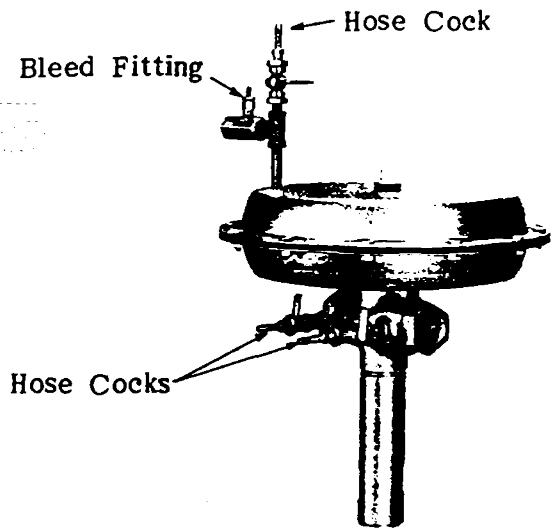
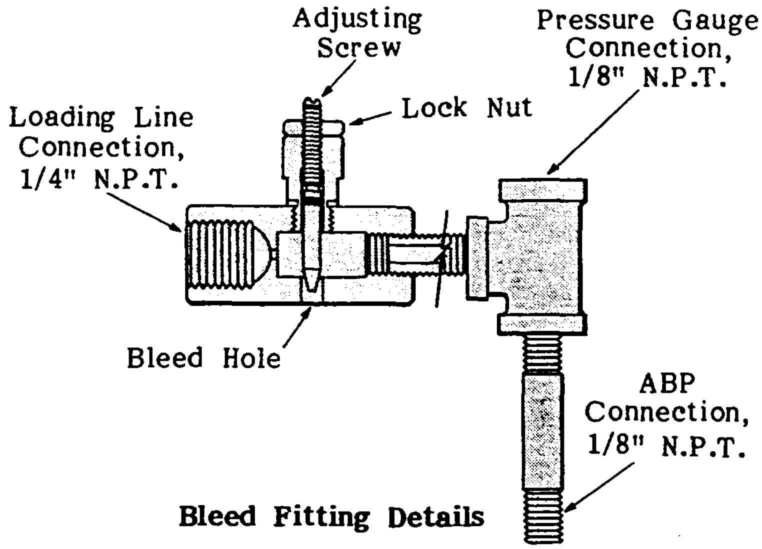


FIGURE 6 - BLEED FITTING





Bleed Fitting Details

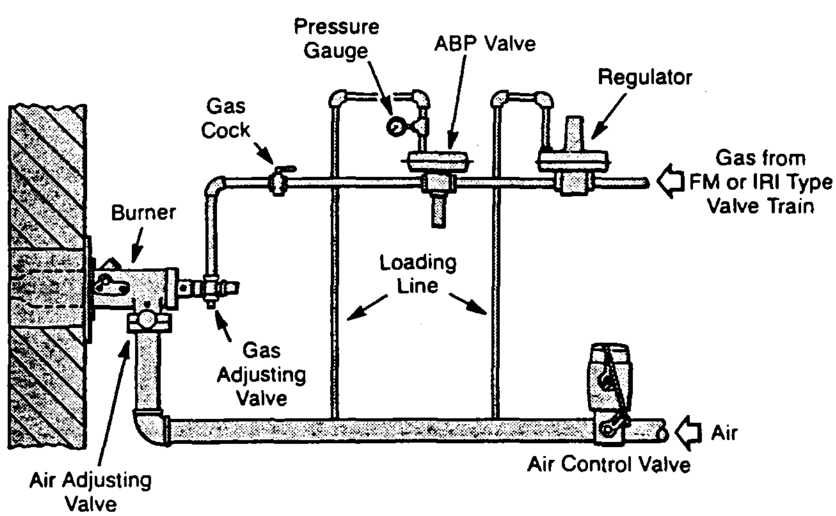
FIGURE 7 - ABP LEAKAGE RATES* With Valve Closed

Catalog Number	ABP Gas Inlet Pressure Minus Loading Line Pressure				
	8"W.C.	14"W.C. (0.5 psi)	28"W.C. (1.0 psi)	42"W.C. (1.5 psi)	55"W.C. (2.0 psi)
104 ABP	16	21	30	37	42
106 ABP	32	42	60	74	85
108 ABP	54	71	100	123	141
112 ABP	67	88	125	153	177

*Capacities listed are for natural gas at .65 sp. gr. For other gases, multiply capacities by these factors: Butane, .548; propane, .628; air, .775.

Do not use on ABP if minimum flow required under any condition is less than the leakage rate listed.

FIGURE 8 - SYSTEM WITH HIGH GAS PRESSURE



2.3 If ABP outlet pressure is lower than loading line pressure, a bleed fitting must be installed (Figure 6). If a bleed fitting is required, use of an air filter is strongly recommended. This will prevent problems caused by dirt in the combustion air. **For reliable ratio control, filter elements must be regularly maintained.**

2.4 By design, ABP's permit a small amount of leakage even with the valve closed, Figure 7. If the ABP has been properly sized, it will have at least 80 to 1 flow turndown, so system control shouldn't be adversely affected. However, if the furnace or oven must operate at gas flows below the leakage rate, provision must be made to avoid temperature overshooting. Contact your Eclipse representative for alternative low fire arrangements.

2.5 Some systems require an ABP outlet pressure of 2.0 psig or higher to achieve rated burner capacity. As the system approaches low fire, loading line pressure may drop more than 2.0 psig below ABP inlet pressure. To prevent ABP damage, a regulator can be installed upstream of the ABP. The regulator's diaphragm is then connected to the air loading line. See Figure 8. A separate loading line should be used for each valve to prevent feedback and possible oscillation between the two valves.

2.6 Some systems incorporate a high pressure air purge in the burner start up cycle to clear the system of any unburned gas. If the loading line pressure during this purge exceeds 2.0 psig, the ABP may be damaged. This can be avoided by installing a solenoid valve in the loading line. The solenoid closes before the purge to isolate the ABP from the high loading line pressure, then opens afterward to allow normal system control. If the system described in the previous step is being used, a solenoid should be placed in each loading line to protect both the ABP and the regulator.

3.0 INSTALLATION

3.1 THE ABP must be installed upstream of gas flow adjusting tees or cocks, downstream of all safety shut-off valves.

3.2 Gas flow through the ABP must be in the direction indicated by the arrow on the side of the ABP body.

3.3 The ABP must be installed with the adjusting stem pointing straight down. Do not tilt the ABP, as this can cause sluggish operation and poor low fire repeatability. **Caution: Be sure to allow sufficient clearance beneath the stem for bias adjustment.**

3.4 The loading line must be at least 1/4" ID and should be as short as possible with as few bends as possible.

3.5 The loading line should be connected to the top of the main air manifold to keep dust and contamination from clogging the line. Connection should be at least two manifold diameters upstream and five manifold diameters downstream of any valve or other restriction.

3.6 Test cocks with hose connections should be installed as shown in Figure 6.

4.0 ADJUSTMENT LOCATIONS

4.1 To adjust the turndown response of the ABP, remove the three screws, cover plate, and gasket from the end of the valve tower. Use a screwdriver to turn the adjusting screw as described in the following section. **Caution: Do not unscrew the adjusting screw past the bottom of the tower, as the screw may fall out, allowing gas to leak into the atmosphere.** Always replace the tower cover plate after making adjustments.

4.2 To adjust the bleed fitting, loosen the locknut by turning it counterclockwise. Turn the bleed fitting screw as described in the following section, then tighten the locknut.

5.0 SYSTEM START-UP

(If your system has no bleed fitting, disregard any steps marked with an asterisk.)

Caution: If loading line pressure or ABP inlet pressure exceed 2.0 psig in your system, make sure during system set-up that the differential pressure between loading line and gas inlet will not exceed 2.0 psig. Higher differential pressures will damage the valve.

5.1 **Set burner air flow** according to the instructions furnished with the burner(s). Turn the air flow to high fire.

*5.2 **Adjust the bleed fitting** to produce a loading line pressure equal to the estimated ABP high fire outlet pressure.

5.3 **Apply gas pressure** to the ABP inlet but do not let gas flow to the burners.

*5.4 **Adjust the bleed fitting** until the ABP inlet pressure minus the loading line pressure is equal to the pressure drop across the valve required to achieve high fire capacity.

5.5 **Turn the combustion air to low fire** flow.

5.6 **Ignite the burner(s)** following the information provided with the burner(s). Adjust the individual burner gas valves for a lean low fire flame.

5.7 **Turn the combustion air to high fire** flow, making sure the burners remain lit.

5.8 **Adjust the burner gas valve(s)** to produce the desired high fire gas input.

5.9 **Turn the combustion air to low fire** flow. Measure the fuel/air ratio using flue gas analysis or metering orifices, or estimate the fuel/air ratio from flame appearance. Turn the ABP bias adjusting screw to produce the desired low fire fuel/air ratio.

5.10 **Cycle the system** between high and low fire several times, checking to be sure the system is adjusted properly at all firing rates.

6.0 TROUBLESHOOTING

6.1 **Burner operates too lean at high fire.**

Check ABP outlet pressure vs. loading line pressure at diaphragm pressure gauge correction.

If outlet pressure is less than loading line pressure:

a) Insufficient gas presure at ABP inlet, due to setting of main pressure regulator or undersized piping. Increase inlet pressure to ABP, but do not exceed limits stated in Section 1.0.

b) ABP is undersized for this application. Recheck capacities in Figure 2 and replace ABP with a larger size regulator.

c) Torn or punctured ABP diaphragm. Replace diaphragm.

If outlet pressure is approximately equal to loading pressure:

d) Burner gas adjusting valve may be closed too far. Re-adjust valve.

e) Dirt or obstruction in line or valves between ABP and burner. Clean line.

f) Piping or valves between ABP and burner are undersized. Replace with properly sized valves and piping.

g) Incorrect loading line pressure at ABP. This can be caused by:

1) Leaking loading line. Check and tighten all fittings.

2) Incorrect loading line tap installation in combustion air line. Correct per Figure 3.

3) Partially closed manual air valve between control valve and loading line Relocate loading line tap per Figure 3.

If ABP is fitted with a bleed fitting:

h) Filter ahead of bleed fitting may be plugged with dirt. Clean or replace filter element.

j) Dirt in bleed fitting orifice. Clean and reset bleed fitting.

6.2 Burner operates too rich at high fire.

Burner gas adjusting valve is open too far. Re-adjust valve.

6.3 Burner goes too lean at low fire.

ABP adjusting screw is turned too far clockwise. Readjust.

6.4 Burner goes too rich at low fire.

a) ABP adjusting screw is turned too far counterclockwise. Readjust.

b) Dirt on ABP valve seat or damaged seat. Inspect seat. Clean and replace if necessary.

c) Inadequate ABP spring force. Conditions may call for a stiffer spring. See spring selection data in Figure 5.

d) Leakage rate of ABP exceeds low fire gas requirements of combustion system. See Section 2.4 for leakage rates and a control system that will permit higher turndowns.

6.5 ABP operation is sluggish.

a) Obstruction in loading line or bleed fitting. Dismantle & clean.

b) ABP internals not moving freely. Make sure ABP is installed with the spring tower pointing straight downward.

c) Dirt inside ABP.

6.6 Replacement parts:

Spring: 104 & 106 ABP - #12315 (Red—standard)
#12325 (Yellow—high pressure)
108 ABP - #12315
112ABP - #12317

Diaphragm: All sizes, #11553

Bowl Gasket: All sizes, #12072.

VII **CATALYST** (if applicable)

A. General Description

ThermTech catalyst is an extremely active precious metal catalyst having a liteoff temperature limit of 600°F and a maximum temperature limit of 1250°F. Typically, a field catalytic oxidizer such as the **VAPOR CHECK** system, a temperature rise of approximately 25°F across the catalyst bed will occur for each 1.0% of the hydrocarbon LEL passing through the bed. For specific applications, contact ThermTech with the exact chemical analysis.

The destructive efficiency of the catalytic system is directly related to the catalyst bed temperature, the quantity of catalyst, and the actual physical condition of the catalyst. The destructive efficiency of the catalytic system can be improved by either increasing the amount of catalyst or the bed inlet temperature while assuring the exit temperature does not exceed the upper temperature limit of operation. If the catalyst is in good condition (no deactivation has occurred), the difference between 50% destructive efficiency and 99% destructive efficiency will be directly related to the amount of catalyst and the temperature of the bed.

The distinct advantage of catalytic operation is lowered fuel gas consumption compared to thermal units. There are inherent disadvantages also. Catalyst of all types, can be poisoned by lead, sulfur, chlorinated hydrocarbons, silicon and phosphorus containing compounds. The result of this deactivation is a reduction in destruction efficiency. Trace amounts of these compounds may not lower the catalyst activity or decrease life expectancy, but appreciable quantities must be removed from the vapor stream. In addition to the compounds mentioned, any particulate matter may cover or mask the catalyst surface, there by reducing catalytic activity. Check with Factory for written recommendations specifically addressing the process stream.

B. Catalyst Inspection

The catalyst block(s) and tray(s) must be inspected to insure damage has not occurred during transportation and handling. Inspect catalyst for any physical damage. Damage will be seen as an abnormality in the catalyst surface, such as scratches, dings, or nicks on the outside of the catalyst module(s). These damages should be noted on the receiving slip to insure liability for restoration with the proper party. A good practice is receive the catalyst **"OK pending further inspection"**.

C. Conversion form Thermal to Catalytic Operation

The catalyst tray(s) with catalyst block(s) shipped with the unit in a separate box must be located. Review each tray to insure the catalyst block is secure in the tray and there is a tight seal with ceramic fiber between the tray and block.

The oxidizer must cool down to ambient temperature before removing the access door on the snub stack. Once the across door is removed, locate the seams in the ceramic fiber on each side of the stack. There are steel guides welded on the stack walls at these seams for the trays to rest on.

Slide the catalyst tray(s) into these guides and push the tray(s) tight to the back wall. Should you experience snagging of the ceramic fiber as the tray is inserted, use the two (2) galvanized metal guides shipped with the catalyst to prevent this.

The lowest catalyst block must have the test coupon installed on the inlet side. Refer to the catalyst manual for exact location. Inspect the ceramic fiber to insure there are no gaps to allow the heat to reach the steel of the stack. The access door should now be replaced. The ceramic fiber anchored to the door must fit tight to the catalyst tray(s) to maintain the seal at the perimeter of the tray.

The start up sequence of catalytic operation stays the same as for the thermal mode. The main difference is the temperatures set points. There are three (3) set points required to be reset, by factory trained personnel only.

1. **TIC503A set point two (2) from 1410°F to 600°F.**
2. **TIC503A Alarm 2 (TSH2503A) set point from 1400°F to 550°F.**
3. **TISH504A set point from 1500°F to 1250°F.**
4. **Alarm 1 is factory pre-set at 140°F and is not to be changed.**
5. **TIC504B (if applicable) from 1475°F to 1225°F.**

With the set points reset, start the system. Once at operating temperature, gradually open the process stream flow control valve. A LEL monitor and a FID unit may be connected to the system, process piping and stack respectively, sampling the gases to insure proper destructive efficiency.

An simplified method to determine proper destructive efficiency is to measure the LEL of the incoming process stream and the temperature rise across the catalyst bed and compare the measurements. Every 1.0% LEL will cause an approximate 25°F gradient temperature rise across the catalyst bed. Example, 10% LEL x 25°F equals 250°F, therefore 600°F should be measured at the catalyst bed inlet and 850°F at the outlet. Should the temperature gradient not be present, something may be wrong. Insure the LEL monitor is operating correctly, check the effluent gas stream with a FID (insure correct zero and calibration) for proper destructive efficiency. The simplified method is an approximate measurement. For accurate destruction efficiencies bag sample must be taken to a lab for complete analysis.

Minimum effluent temperature from the catalyst bed should be 750°F.

Refer to the catalyst manual for further information.

To revert back to thermal operation, the above set points must be reset back to thermal mode set points by factory trained personnel. The catalyst tray(s) and block(s) must be removed. Before removing the access door, cool the oxidizer down to ambient temperature. Remove the trays and inspect the ceramic fiber at the seams to insure there is a tight seal to eliminate heat reaching to the outside steel.

D. Catalyst Maintenance

Periodically, the catalyst must be inspected. Perform the destructive efficiency tests described above. If the tests prove problems may exist, refer to the catalyst manual for regenerations procedures. If problems still exist, contact ThermTech for more extensive regenerative procedures. After several regenerations or shorter intervals between regeneration, the catalyst will need to be replaced.

VIII HEAT EXCHANGER (if applicable)

A. General Description

The heat exchanger is utilized to recover heat from the exhaust flue gas to preheat the process stream to conserve fuel gas costs on the initial system preheat and during decreasing hydrocarbon concentrations. The ThermTech, Inc. standard heat exchanger will preheat the process stream to approximately 700°F, a 48% effective recovery, for thermal operation. Catalytic operation will have approximately a 40% effective recovery.

The heat exchanger is a tube and shell design constructed of 304 stainless steel, all welded and pressure tested to insure no cross contamination.

B. Maintenance

The heat exchanger is a high quality, static device with no moving parts. There are no user serviceable parts inside. Periodic visual inspection of the tubes and welds is recommended.

C. Heat Up Notes

All heat exchangers have a maximum heat up rate, as well as a maximum continuous operating temperature, a ThermTech, Inc. heat exchanger is no different. This rate is 200°F - 1410°F for 20 minutes for thermal operation and is controlled automatically by the pre-programmed setpoint ramp temperature controller (TIC503A). The maximum continuous operating temperature is 1500°F.

Upon conversion of the ThermTech unit to catalytic operation, the final set point on the temperature controller (TIC503A) is 600°F instead of 1410°F. In the catalytic mode of operation, the operator is in control of the systems ramping rate with the manual dilution air and process flow control valves.

A ThermTech turnkey vapor extraction system is ideally suited to control the ramp/soak requirement. At the start of catalytic operation, insure the flow control valve going to the process is closed and the manual dilution air valve is open. After the high temperature dilution valve closes allowing a vacuum to be applied to the process, open the flow control valve in small increments and wait at least one (1) minute before opening the valve more. This minute is to allow the system time to react. This reaction will be a temperature increase at the catalyst bed outlet and indicated on the high temperature shut down controller (TISH504A). Gradually open the flow control valve until completely open, then using the same procedure, gradually, very gradually, close the manual dilution air valve. This procedure allows higher vacuum levels and flow from the process and the potential of higher hydrocarbon concentrations being supplied to the system. The greater concentrations, the larger the temperature difference across the catalyst bed, and the higher the temperature seen by the heat exchanger.

The ultimate goal is to limit the temperatures seen by the heat exchanger to those temperatures shown in the ramp/soak chart below.

Step	**Temperature (°F)**	**Ramp Rate (min)**	**Soak Time (min)**
1	0-700	5	5
2	700-800	1	1
3	800-900	1	1
4	900-1000	1	1
5	1000-1225	2	Final Setpoint

These instructions have been clarified as to insure maximum life and protection of the heat exchanger and it's warranty.

If any questions should arise during installation or operation, do not hesitate to contact ThermTech service department at (281)359-7542.

IX MAINTENANCE

A. Maintenance

A scheduled maintenance program should be established based upon the site and process conditions. Operation frequency and duration, process stream contaminants and quantity of particulate matter, and elements of nature are conditions to determine maintenance frequency. The following table is a suggested time table for maintenance, this table should be used as a guideline.

Monthly
- Inspect all connections for tightness and leaks.
- Inspect all filter elements and if required clean or replace.
- Remove pressure switch PSL201 and PSL310 sensing lines to insure pressure switches are operational.
- Simulate or induce system failures to insure proper and safe operation.
- Remove flame arrestor drain plugs and drain any liquids. Liquid may be considered a hazardous waste, dispose of properly.

Semi annually
- Inspect the flame monitoring device(s) and maintain with manufacturer's instructions.
- Check and/or replace grease and/or oil in process blower(s) and grease motors and bearing pillow blocks at required time intervals, refer to manufacturer's instructions.
- Oil the linkage swivels of any electrically or pneumatically controlled valve.
- Grease all valve which require greasing, i.e. 6" and 8" butterfly valve of TCV202.

Annually
- Inspect the ceramic fiber insulation for tearing, shrinking or any sign of movement. Replacement of the working layer is easily accomplished by loosening the washers, taking off the damaged area and replacing it with a slightly oversized piece.
- Visually inspect heat exchanger tube and welds.

General-continual
- Skid must kept clean of debris.
- Paint on the unit should be kept up to prevent the obvious hazard of rust.

Preventative maintenance is important, but minimal. It is understood that if obvious problems do occur, they are handled in a timely fashion, so to get the best life possible from the system.

B. Trouble Shooting

CAUTION
There is hazardous voltage in e system. Voltage testing should be done only by qualified persons.

NOTE: To test the operation of the pilot lights (except power on (PL1)), turn disconnect on and reset emergency stop push button and depress the lamp test push button (PB4) on the front of the control panel.

1. Power on pilot light (PL1/JAH500) in not lit:

   a. Insure disconnect switch is on
   b. Verify power to the disconnect
   c. Verify fuses are not blown in disconnect and at XFMR #1 primary and secondary
   d. Reset GFCI
   e. Verify pilot light bulb (PL1) is operational and replace if necessary

2. Combustion Blower Running pilot light (PL2/JAH1003) is not lit

   - Combustion blower not running:

   a. Verify power to C1 contactor
   b. Verify emergency stop button (PB1) is reset
   c. Test for 120V at coil of C1, wire #86A.

      - read 120V, contactor does not "pull in" replace coil
      - read 0V, go to step d

   d. Test for 120V, on C1 overload, wire #86

      - read 120V, reset overload
      - read 0V, go to step e

   e. Check for a system shutdown, if so T3 may be energized and time out, refer to section X and reset alarms

   - Combustion blower running:

   a. Replace pilot light bulb (PL2)

3. Oxidizer on Pilot light (PL9/JAH502) is not lit

   a. System has shut down due to a failure, check for failure lights
   b. Insure oxidizer on/off switch (SS1) is on
   c. Replace pilot light bulb

4. Power Interruption pilot light (PL15/JAL500) is lit

NOTE: System shipped from factory with power interruption shutdown disabled, if shutdown is required remove the blue jumper wire on the voltage sensing relay (VSR) between pin 6 and 8. Although disabled, power interruption will still indicated.

   a. Reset power interruption via PB3

      - If light does not clear, test for 120V, XFMR #1 secondary voltage
        - read 95V or more, replace VSR
        - read less than 95V, test for 240V/480V, XFMR #1 primary voltage
          - read 240V/480V, replace XFMR #1
          - read less the 240V/480V, verify a disconnect and/or a primary fuse is not blown

5. Pilot Solenoid (XV101) will not energize (open) after the 1.5 minute purge cycle (Results in Flame Failure and Control Fault (PL6/YA502))

   a. Verify T2 timer is set for interval mode and 70-90 seconds
   b. Test for 120V at terminal block 5

   Voltage will only be present from the time the unit finishes the 1.5 minute purge cycle until it shuts down on flame failure and control fault.

      - read 120V, replace pilot solenoid coil, consult factory
      - read 0V, go to step C.

   c. Test for 120V at T2 pin 5

   Voltage will only be present from the time the unit finishes the 1.5 minute purge cycle until it shuts down on flame failure and control fault.

- read 120V, replace T2
- read 0V, reset power interruption and/or replace flame safe guard relay (BY502), consult factory

6. Pilot solenoid (XV101) energizes (opens) but flame does not light (Results in Flame Failure and Control Fault)

   a. Verify all manual valves on the fuel gas train are open
   b. Test for 120V at terminal block 6

   Voltage will only be present from the time the unit finishes the 1.5 minute purge cycle until it shuts down on flame failure and control fault.

   - read 120V, replace ignition transformer, spark plug or spark plug wire, consult factory
   - read 0V, replace BY502, consult factory

7. Pilot solenoid (XV101) energizes (opens), flame lights (as verified through burner sight glass) but system shuts down on Flame Failure & Control Fault

   a. Remove UV scanner (BE502) and check lens for damage. Clean UV scanner lens and reinstall
   b. Insure there is good contact between terminal blocks S1 and S2 and the respective wires going to the UV scanner
   c. Remove UV scanner from burner, turn power on and turn SS1 on. Put a flame source in front of the UV scanner and view the flame intensity meter (BI502).

      - Flame intensity meter (BI502) displays a DC voltage, replace purge relay (BY502), contact factory
      - Flame intensity meter (BI502) displays no DC voltage, replace UV scanner (BE502), consult factory

8. Main fuel gas solenoid will not energize (open)

   a. Insure Oxidizer run/low fire switch (SS2) is in the low fire

In low fire the oxidizer at low fire pilot light (PL8/ZAL202) should be illuminated, the actuator (TCV202) should be in low fire position (closed), and R1 relay should be energized. If PL8 is not on and R1 is not energized but TCV202 is in the low fire position insure limit switch ZSL202 in TCV202 is closing in low fire.

b. Test for 120V at terminal block 22

- read 120V, replace main gas solenoid coil
- read 0V, go to step c

c. Test for 120V at terminal block 1

- read 120V, replace R1 relay, substitute R6 for R1 to verify defective relay
- read 0V, replace BY502, consult factory

9. Main fuel gas solenoid (XV105) de-energizes (closes) when oxidizer run/low fire switch (SS2) is turned to run

   a. Main fuel gas locktite manual valve (XV104) has not been reset (opened)

10. Main fuel gas locktite manual valve (XV104) will reset

    a. Oxidizer run/low fire switch (SS2) is not in low fire

    In low fire the oxidizer at low fire pilot light (PL8/ZAL202) should be illuminated, the actuator (TCV202) should be in low fire position (closed), and R1 relay should be energized. If PL8 is not on and R1 is not energized but TCV202 is in the low fire position insure limit switch ZSL202 in TCV202 is closing in low fire.

    b. Test for 120V at terminal block 22

    - read 120V, replace solenoid coil in XV104, consult factory
    - read 0V, go to step c

c. Test for 120V at terminal block 1

- read 120V, replace R1 relay, replace R1 with R6 to verify defective relay
- read 0V, replace BY502, consult factory

11. Process blower will not turn on

a. Verify power to process blower contactor
b. Verify overload is not tripped
c. Verify that the fuses are not blown
d. Insure alarm #1 (TSH1503A) set point in temperature controller (TIC503A) is 140°F and R2 is energized when TSH1503A is energized
e. Test for 120V at C2 contactor coil, wire 28B

- read 120V, but starter does not "pull in" replace coil
- read 0V, go to step f

f. Test for 120V at C2 overload, wire #86A

- read 120V, reset overload
- read 0V, go to step g

g. Test for 120V at terminal block 28

- read 120V, motor winding temperature switch (TSH-1002) is open let motor cool off or have it checked by an authorized motor repair shop
- read 0V, go to step h

h. Verify R2 is energizing when TSH1503A is energized

12. High Temperature Dilution Air Valve (TCV600) fails to operate

a. Verify alarm #2 (TSH2503A) set point in TIC503A is correct
Thermal - 1400° F
Catalytic - 550° F
b. Insure manual override (black knob) on top of TCV600 actuator is disengaged (pulled up)
c. Insure system is not in a high temperature shutdown condition - TCV600 would be open
d. Test for 120V at terminal blocks 24 or 41.

If the system is at operating temperature and above TSH2503A set point, TCV600 should be closed.

- 120V should be on terminal block 24

If the system is below operating temperature and below TSH2503A set point, TCV600 should be open

- 120V should be on terminal block 41

e. If you cycle the system above and below TSH2503A set point and get the above voltages, the problem may be at TCV600 actuator. Remove the actuator cover and verify the above voltages at the corresponding wire numbers. This will eliminate or prove a possible loose connection problem.

f. If the 120V does not switch from terminal block 41 to terminal block 24, as the system goes reaches TSH2503A set point, test the following:

For the following voltage checks the unit must be above TSH2503A set point. Either bring the system up to operating temperature or lower TSH2503A set point for the purpose of trouble shooting. When TSH2503A set point is energized a small 2 will be illuminated in the TIC503A display.

- Test for 120V at R6 pin 2
    - Read 120V, replace R6 substitute R1 for R6 to verify defective relay
    - Read 0V, go to next step
- Test for 120V at R3 pin 11
    - Read 120V, verify R3 is energized, if not system is in a high temperature shutdown. Refer to section X
    - Read 0V, replace TIC503A, consult factory

13. Process line block valve (XV304) will not reset/open

See step 10 above

14. System shuts down on control fault only (no other fault lights)

    System has shutdown either on air failure or flame failure as indicated on BY502. It is necessary to open the panel (without turning off power) to see which light is lit on the flame safe guard relay (BY502).

    - Air Failure will result from:
        - Combustion blower failure
        - Process blower failure
        - High liquid level in KO pot (if applicable)
        - Interlocks from other equipment connected to the J1 terminal blocks (Note 1 on control schematics)

    Combustion blower failure and remote dry contact will not have an associated external fault light

    - Flame failure will result from a loss of flame or flame signal only, refer to step 5, 6 and 7

15. Combustion air blower failure

    - blower not running

    a. see step 2

    - blower running

    b. Verify PSL201 is operating properly and set point is correct

16. Flame failure

    Refer to Steps 5, 6, and 7

17. Process blower failure

    - blower running

    a. Verify PSL310 is operating properly and set point is correct
    b. Verify all manual valves are in the correct position.

c. Verify all automatic valves are in the correct position.

   - TCV600 and XV304

d. Verify process flow to the oxidizer
e. Check for an abnormal pressure/vacuum

   - Extremely high pressure would indicate a blockage at the flame arrestor and/or catalyst (if applicable)
   - Extremely high vacuum would indicate a blockage on the vacuum side of the blower.
     - Check for a high reading on the Knockout Pot Δ P magnehelic (PDI301) which would indicate the K.O. pot demister pad is plugging.

       - remove clean or replace the demister pad

- blower not running

  Refer to step 11

18. High/Low Fuel Gas Pressure pilot light (PL11/PAHL106) is lit (control fault also indicated)

    a. Verify supply fuel gas pressure is five (5) PSIG minimum
    b. Verify all manual valves are open
    c. Verify setpoint of main gas pressure regulator (PCV102) is correct, check for damaged diaphragm
    d. Verify setpoint of fuel gas pressure switches (PSL103 and PSH106) is correct
       - if correct, replace switch

19. High Temperature Shutdown pilot light (PL5/TAH504A) is lit (control fault also indicated)

Should the system shut down due to high temperature limits being reached, the operator must, without fail, check the VOC levels of the burner chamber of the oxidizer to insure that an explosive situation does not exist. The burner chamber can be checked by removing the manway to access the vapors possibly resident in the chamber. The vapor levels in the chamber can be tested with an LEL monitor and there should be no recordable hydrocarbons at this point as the unit is designed to have purged after shut down. Should a measurable level be indicated, liquid hydrocarbon has reached the burner chamber and may have saturated the ceramic fiber insulation. An explosive situation exists and must be rectified. Contact ThermTech for instructions before proceeding.

a. Verify temperature display on high temperature shutdown controller (TISH504A) is same as or close to the temperature displayed on TIC503A

- temperatures displayed on controllers are not the same or close (within approximately 2% of each other)
    - verify thermocouple wire connections are tight between thermocouples and respective controller
        - if connections are tight, calibrate thermocouple(s) or replace thermocouple(s)
- temperature display on TISH504A is approximately 2400°F, replace thermocouple TE504A

20. Improper or fluctuating DRE of process stream flue gas

a. Verify settings of burner system (fuel train and combustion air) are correct to achieve complete combustion of purchased fuel

- Verify combustion air blower inlet filter element is clean, replace if needed

b. Verify there is sufficient O_2 in the process stream

c. Verify samples were taken properly (i.e. clean tubing, sample transported to lab correctly, etc.)
d. Verify process stream flow rate does not exceed system design SCFM rating

21. System will not reach operating temperature

a. Verify settings of burner system (fuel train and combustion air) are correct, check filter elements for clean
b. Verify process stream flow rate does not exceed system design SCFM rating

X Safety Shutdowns

Oxidizer/VES System Panel

There are fifteen (15) operational/fault pilot lights on the oxidizer panel labeled as follows:

1. Power On
2. Combustion Blower Running
3. Oxidizer On
4. Oxidizer at Low Fire
5. Pilot Gas Solenoid Open
6. Main Gas Solenoid Open
7. Control Fault
8. High Temperature Shutdown
9. Power Interruption
10. High/Low Gas Pressure
11. Process Blower Running
12. Process Blower Failure
13. High Temp Dilution Valve Open
14. High Temp Dilution Valve Closed
15. High Liquid Level (if applicable)

Note: There is a DC voltmeter to indicate burner (flame) intensity thereby eliminating the need for the operator to use the observation port to insure the pilot or burner is lit.

The operation of the lights can be tested by turning the disconnect on, reset the emergency stop push button (PB1) and depressing the lamp test push button (PB4) located on the front of control panel.

There are **two (2) purposes** for these lights indicating the operations they indicate:

1. The operator will be aware of system status at all times.

2. Should the system fail to operate correctly, or should the system shut down, there will be an indication to the cause of the shutdown.

The Oxidizer system is designed to shut itself down for any of the following reasons:

1.	High Fuel Gas pressure	PSH106 (over 28" wc)
2.	Low Fuel Gas Pressure	PSL103 (under 6" wc)
3.	Loss of flame/no ignition	BE502
4.	Process blower failure	PSL310 (± 0.5" wc)
5.	Exceeding high temperature limit	TISH504A (1500°F)
6.	Power interruption	VSR relay (23% voltage drop)
7.	Combustion air blower failure	PSL201 (± 0.5" wc)
8.	Knockout Pot High High Level	LSHH303 (± 11 gal)

All of the above faults will shut down the oxidizer and VES system. The process blower and combustion will continue to run in a post purge/cool down cycle.

Should the system shutdown, the unit will not restart. Manual restart must be initiated by the operator.

Power interruption shutdown has been disabled when shipped from the factory. It can be enabled by removing the blue jumper wire connected to VSR relay pin 6 and pin 8.

A power interruption or a voltage drop of 23% will shutdown the system. When power is restored the system will indicate a power interruption has occurred along with other numerous faults. **Absolutely no assumptions should be made; proceed with the instructions in the following paragraph.**

Should the system shut down due to high temperature limits being reached, the operator must, without fail, check the VOC levels of the burner chamber of the oxidizer to insure that an explosive situation does not exist. The burner chamber can be checked by removing the manway to access the vapors possibly resident in the chamber. The vapor levels in the chamber can be tested with an LEL monitor and there should be no recordable hydrocarbons at this point as the unit is designed to have purged after shut down. Should a measurable level be indicated, liquid hydrocarbon has reached the burner chamber and may have saturated the ceramic fiber insulation. An explosive situation exists and must be rectified. Contact ThermTech for instructions before proceeding.

XI Instrument List

A. Mechanical Components

FUNCTION	TAG	MANUFACTURER	PART #
Oxidizer			
Pilot Regulator	PCV100	Eclipse/Equimeter	½" 043-182
Pilot Solenoid Valve	XV101	Eclipse/ASCO	ECC-504
Main Fuel Gas (FG) Regulator	PCV102	Eclipse/Equimeter	1" 143-8-2 VAC10/25/50 1½"243-8-2 VAC75/100/150
FG Low Press. Switch	PSL103	Dwyer	1950-10-2B
FG Locktite Valve w/Manual Reset	XV104	Eclipse	204-LT-IS-3 VAC10/25/50 206-LT-IS-3 VAC75/100/150
FG Solenoid Valve	XV105	Eclipse/ASCO	48408 VAC10/25/50 48412 VAC75/100/150
FG High Press. Switch	PSH106	Dwyer	1950P-2-2B
FG Flow Orifice	FE107	Eclipse	FOM 4-2 VAC10 4-5 VAC25 6-4 VAC50/75 6-5 VAC100/150
FG Flow Indicator	FI107	Dwyer	Magnehelic 2003 SPEC VAC10/25/50 Magnehelic 2005 SPEC VAC75/100 Magnehelic 2010 SPEC VAC150
FG Proportionator Valve	FCV108	Eclipse	104-ABP VAC10/25/50 106-ABP VAC75/100/150
Press. Indicator	PI109	Dwyer	Magnehelic 2030 SPEC VAC10/25/50/75/100 Magnehelic 2050 SPEC VAC150
Comb. Air Filter		Universal	CCS-2 VAC10 CCS-3 VAC25 CCS-4 VAC50 CCS-6 VAC75/100/150
Comb. Air Blower	B-1003	Eclipse	SMJ4615-¼ VAC10 SMJ4615-1 VAC25 SMJ4616-1 VAC50 SMJ6619-3 VAC75 SMJ4617-3 VAC100 SMJ6619-5 VAC150
Comb. Air Switch	PSL201	Dwyer	1950-0-2F

Comb. Air Flow Valve	TCV202	Eclipse	8BVAR VAC10 12BVAR VAC25 16BVAR VAC50/75 24BVAR VAC100/150
Actuator		Barbara Coleman	EMP 424-4
Linkage kit		Eclipse	500928
Comb. Air Diff Press	PDI501	Dwyer	Magnehelic 2003 SPEC VAC10/25/75/100 Magnehelic 2005 SPEC VAC50 Magnehelic 2010 SPEC VAC150
Burner Flame Element w/nylon insulator	BE502	Eclipse	5600-90
adaptor		Eclipse	103004 VAC10 103003 VAC25/50/75/100/150
Thermocouples	TE50*	Eclipse/Pyromation	KK44012G-00-33
Flame Arrestor		Enardo	70804/D-AAF-16 VAC10/25/50 71006/D-AAF-16 VAC75/100 71408/D-AAF-16 VAC150
High Temp Dilution Valve	TCV600	Bailiff w/Automax Actuator	3" VAC10/25 4" VAC50 6" VAC75/100 8" VAC150
Burner	B-1004	Eclipse	82 MVTA VAC10 84 MVTA VAC25 104 MVTA VAC50 168 MVTA VAC75/100/150
VES (if applicable)			
High Temperature Filter/Silencer		Universal	CCS-3 VAC10/25 CCS-4 VAC50 CCS-6 VAC75/100 CCS-8 VAC150
Total Vacuum gage	PI300	Dwyer	Magnehelic 2150
KO Pot	V-1001	ThermTech	100-010-01096 VAC10/25 100-010-01097 VAC50 100-010-01099 VAC75/100 100-010-01112 VAC150
KO Pot Diff Press	PDI301	Dwyer	Magnehelic 2080
Level Gauge	LG302	Kenco	5700-15.75-CVL
Level Switch	LS*303	Gems	113830

Shutdown Valve	XV304	Eclipse	212LT-IS-3 VAC10/25 216LT-AF-3 VAC50
		Maxon	808-29415 VAC75/100/150
Vacuum Relief	PVSV305	Kunckle Or Lamson	vacuum requirement specific
Process Blower	B-1002	Centrifugal / PD	customer spec
Temp. Indicator	TI307	Ashcroft	30EI60R*50-550°F
Press. Indicator	PI308	Dwyer	Magnehelic 2015 VAC10 Magnehelic 2030 VAC25 Magnehelic 2050 VAC50/75/100/150
Flow Element	FE309	Dwyer	167-6-CF
Flow Indicator	FI309	Dwyer	Magnehelic 2000-00AV VAC10 Magnehelic 2001AV VAC25/75 Magnehelic 2002AV VAC100/150 Magnehelic 2003 VAC50
Process Flow Switch	PSL310	Dwyer	1950-0-2F
KO pot transfer pump	P-1000	Shurflo	2088-433-244
Filter		Shurflo	170-060-00
Dilution air flow element	FE401	Dwyer	167-6-CF
Dilution flow indicator	FI401	Dwyer	Magnehelic 2000-0AV VAC10 Magnehelic 2002AV VAC25/75/100/150 Magnehelic 2003 VAC50

B. Panel Components

FUNCTION	TAG	LABEL	MANUFACTURER	PART #
Fused Disconnect		disconnect	AB	194R-NJ***P3
Operating Handle			AB	194R-H**
Switch Extension			AB	194R-R*
Selector Switch	SS1	oxidizer off/on	AB	800T-H2
Selector Switch	SS2	oxidizer run/low fire	AB	800T-H2
Push/Pull button	PB1	Emergency Stop	AB	800T-FX6D4
Push Button	PB2	Alarm Reset	AB	800T-A2
Push Button	PB3	Power Interruption Reset	AB	800T-A2
Push Button	PB4	Lamp Test	AB	800T-A2
SS1/PB Contact Block			AB	800T-XA2
SS2/PB Contact Block			AB	800T-XA4
SS2/PB Contact Block			AB	800T-XD1
Motor Contactor	C1		AB	100-***ND3
Motor Overload	C1		AB	193-*****
Aux. Contact	C1		AB	195-*A10
Transformer	XFMR#1		Hevi-Duty	E-***
Nema 4 Window			Vynkier	10061.035
Fuse block 3-pole	(class J fuse)		Buss	J60030-3C
Fuse block 2-pole	(class J fuse)		Buss	J60030-2C
Fuse block 3-pole	(class CC fuse)		Buss	B*6033SQ
Fuse block 2-pole	(class CC fuse)		Buss	B*6032SQ
Fuse block 1-pole	(class CC fuse)		Buss	B*6031SQ
Hour Meter	KI503A		Kessler	H57-110 VAC
Voltmeter	BI502	Flame Intensity	Hoyt	3125
3PDT Relay	R*		IDEC	RR3PA-UL-AC120V
3PDT Relay Base	R*		IDEC	SR3P-05
4PDT relay	RT*		IDEC	RY4S-UL-AC120V
4PDT Relay Base	RT*		IDEC	SY4S-05
Timer 1	T1,T2		IDEC	RTE-P11-AC120V
Timer 3	T3		IDEC	RTE-P12-AC120V
Timer Base	T1-T3		IDEC	SR2P-06
Lights Sockets	PL*		Dialco	95-1310-09-301
130 V Bulbs	PL*		Dialco	967
Red Lens	PL*		Dialco	52-0991
Green Lens	PL*		Dialco	52-0992
Flame Safe Guard Relay	BY502		Eclipse	5605-22
Flame Safe Guard Base	BY502		Eclipse	5602-10
High Temperature Controller	TISH504A	High Temp Shutdown	Yokogawa	UT 15 L
Temp Controller	TIC503A	Temp. Controller	Yokogawa	UT 15
Ground Fault Circuit Interruptor	GFCI		Eagle	76472V

Voltage Sensing Relay	VSR	Potter Brumfield	CSJ-38-70010
VES (if applicable)			
Motor Contactor	C-2	AB	100-***ND3
Motor Overload	C-2	AB	193-******
Aux. Contact	C-2	AB	195-*A01
Power Distribution Block	PDB	Gould	67563
P-1000 Power Supply	PS	Elpac	BFS200-12F

* Sizes/quantities vary per system, refer to electrical drawings section XII and review specific component for exact part number.

NOTE: Verify component part number before ordering replacement.

SECTION XII

DRAWINGS

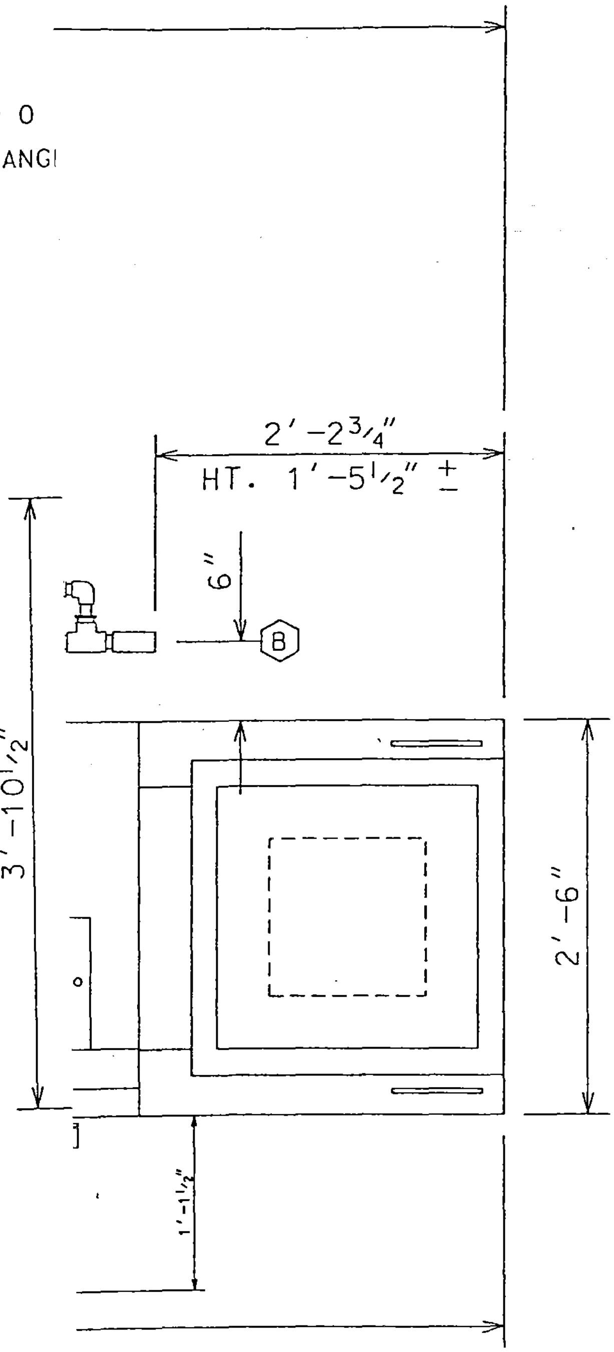
SPECIFICATIONS:

(A) POWER: 240VAC/1PH/60Hz/30

(B) FUEL GAS: 0.24 mmBTU/HR @ 5
1" FNPT

(C) PROCESS: 100 SCFM MAX. @ 0
2" ANSI 150# FLANG

ESTIMATED WEIGHT: 3,500 lbs TOTAL



NOTES

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

NO.

RRANGEMENT

CH INC.

TROL SYSTEMS

AS 1-800-659-8271

JOB NO.	946
JOBSITE	TX
REV. NO.	0
DWG NO.	946GA
PAGE	1 OF 1

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XIII **Spare Parts** (recommended)

A. Mechanical

Qty	Description	ThermTech Part No
1	Dwyer Pressure Switch 1950-0-2F	100-010-40200
1	Dwyer Pressure Switch 1950-10-2B	100-010-40205
1	Dwyer Pressure Switch 1950P-2-2B	100-010-40206
1	Dwyer Magnehelic 2003 Special**	100-010-40269
1	Dwyer Magnehelic 2005 Special**	100-010-40268
1	Dwyer Magnehelic 2010 Special**	100-010-40258
1	Dwyer Magnehelic 2030 Special**	100-010-40266
1	Flow Element (pitot tube)	100-010-40270
1	Level Switch	100-040-40271
1	Thermocouple	100-010-40302
2	Replacement Air Filter Element 3" **	
2	Replacement Air Filter Element 4" **	
2	Replacement Air Filter Element 6" **	
4	Replacement Air Filter Element 8" **	
1	P-1000 filter	100-070-71546

** Sizes/quantities vary per system, review specific component for exact part number.

B. Electrical

Qty	Description	ThermTech Part No
3	Bussman LPJ-***SP class J fuse	
2	Bussman KTK-R-* class CC fuse	
2	Bussman FNM-* class CC fuse	
2	Bussman FNQ-R-* class CC fuse	
1	Allen Bradley Aux Contact 195-BA10	100-070-71138
1	Allen Bradley Aux Contact 195-GA10 (VES)	100-070-71137
1	Allen Bradley Contact Block 800T-XA4	100-070-71050
1	Allen Bradley Contact Block 800T-XA2	100-070-71048
1	Allen Bradley Contact Block 800T-XD1	100-040-71080
1	IDEC 3PDT Relay RR3PA-UL-AC120V	100-070-71395
3	Dialco Pilot Lamp 967	100-070-71455

* Sizes/quantities vary per system, refer to electrical drawings section XII and review specific component for exact part number.

Spare parts should kept be on hand if maximum up time is required. Most replacement parts can be located and delivered within seven (7) days, or sooner if required. Contact ThermTech, Inc. service at (281)359-7542.

SECTION XIV

COMPONENT MANUALS

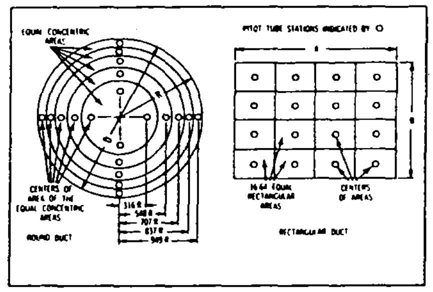
AIR VELOCITIES WITH THE DWYER PITOT TUBE

AIR VELOCITY

The total pressure of an air stream flowing in a duct is the sum of the static or bursting pressure exerted upon the sidewalls of the duct and the impact or velocity pressure of the moving air. Through the use of a pitot tube connected differentially to a manometer, the velocity pressure alone is indicated and the corresponding air velocity determined.

For accuracy of plus or minus 2%, as in laboratory applications, extreme care is required and the following precautions should be observed:

1. Duct diameter 4" or greater.
2. Make an accurate traverse per sketch at right, calculate the velocities and average the readings.
3. Provide smooth, straight duct sections a minimum of 8½ diameters in length upstream and 1½ diameters downstream from the pitot tube.
4. Provide an egg crate type straightener upstream from the pitot tube.



In making an air velocity check select a location as suggested above, connect tubing leads from both pitot tube connections to the manometer and insert in the duct with the tip directed into the air stream. If the manometer shows a minus indication reverse the tubes. With a direct reading manometer, air velocities will now be shown in feet per minute. In other types, the manometer will read velocity pressure in inches of water and the corresponding velocity will be found from the curves in this bulletin. If circumstances do not permit an accurate traverse, center the pitot tube in the duct, determine the center velocity and multiply by a factor of .9 for the approximate average velocity. Field tests run in this manner should be accurate within plus or minus 5%.

The velocity indicated is for dry air at 70°F., 29.9" Barometric Pressure and a resulting density of .075#/cu. ft. For air at a temperature other than 70°F. refer to the curves in this bulletin. For other variations from these conditions, corrections may be based upon the following data:

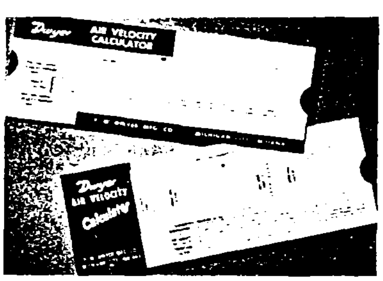
$$\text{Air Velocity} = 1096.2 \sqrt{\frac{P_V}{D}}$$

where P_V = velocity pressure in inches of water
D = Air density in #/cu. ft.

$$\text{Air Density} = 1.325 \times \frac{P_B}{T}$$

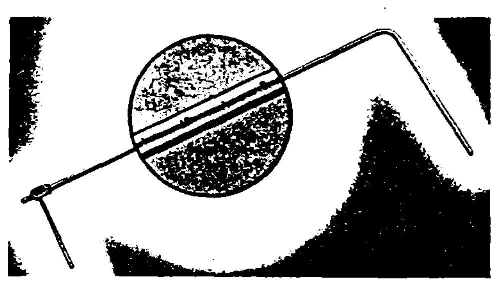
where P_B = Barometric Pressure in inches of mercury
T = Absolute Temperature (indicated temperature °F plus 460)

Flow in cu. ft. per min. = Duct area in square feet x air velocity in ft. per min.



AIR VELOCITY CALCULATOR

Computes velocity based on air density corrected for conditions of temperature and pressure. Eliminates tedious calculations. Ranges from .01 to 10" water corresponding to 400 to 20,000 FPM. Furnished with each pitot tube.



STAINLESS STEEL PITOT TUBES

Test confirmed unity coefficient and lifetime construction of No. 304 stainless steel. Inch graduations show depth of insertion for traversing. Complies with AMCA and ASHRAE specifications. Sizes 12" to 60" long. Hand or fixed mounting types.

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DWYER INSTRUMENTS, INC.
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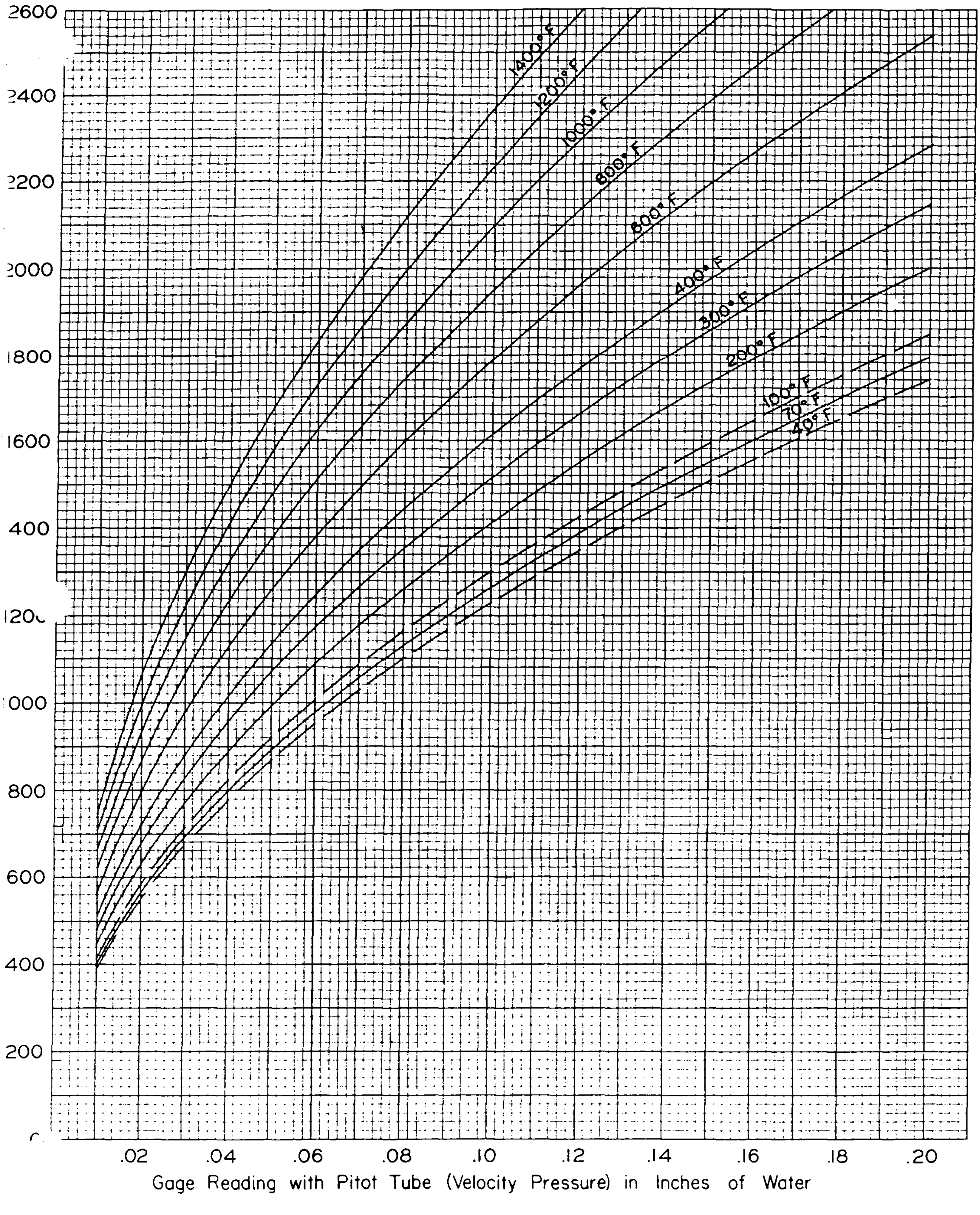
Fax 219/872-9057



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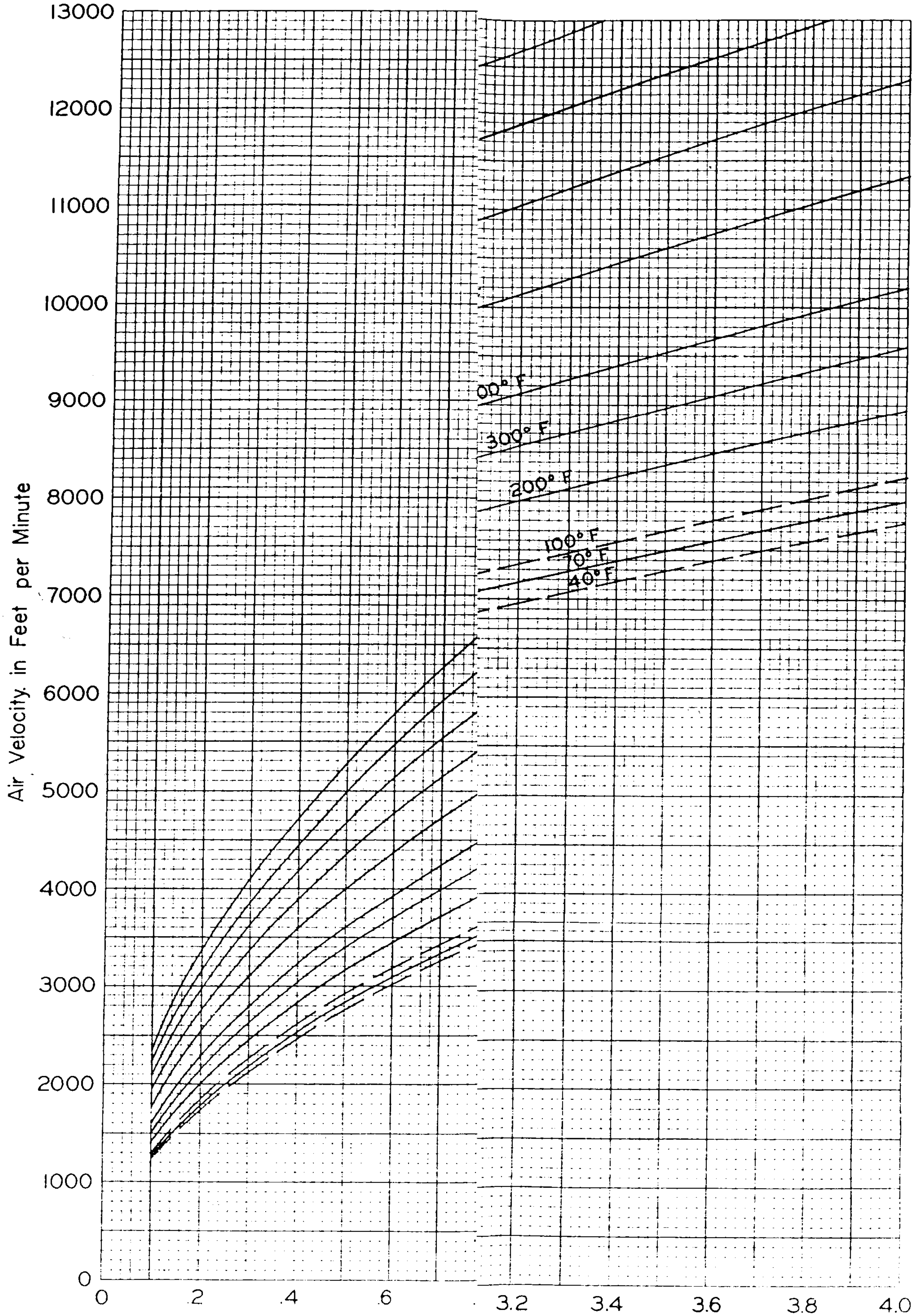


13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Air Velocity in Feet per Minute
0
.2
.4
.6
3.2
3.4
3.6
3.8
4.0
00° F
300° F
200° F
100° F
70° F
40° F

MODEL 70804/D-AAF-16 FLAME ARRESTOR

INSTALLATION & MAINTENANCE

INSTRUCTIONS

Enardo Manufacturing Company * 6523 E. Independence Street * Tulsa, OK 74115

ENARDO MODEL

70804/D-AAF-16 FLAME ARRESTOR

I. MODEL NUMBER IDENTIFICATION:

MODEL: 70804/D-AAF-16 Serial No. ________

7 = Series 7
08 = Housing Size - 8"
04 = Connection size - 4"
D = NEC Gas Group: Group "D"
A = Housing material: Aluminum
A = Cell element material: Aluminum
F = Connection type: Flat face
1 = Optional: Drain Plugs
6 = Optional: Special Features

WARNING

This unit is designed for Group D gas flame propagation with a minimum 0.90 mm. MESG rating at a maximum initial pressure of 15.4 psia.

II. INSTALLATION AND MAINTENANCE INSTRUCTIONS:

A. Installation Instructions

WARNING

Always make sure that the system is at atmospheric pressure and there is no ignitable gas that could flash when either installing or maintaining the unit.

This arrestor should not be operated when an un-arrested flame path exists around the element assembly i.e.: devices such as a differential pressure transmitter that would be connected to both sides of the element assembly or any other hook-up that circumvents the arresting element.

The Enardo Model 70804/D-AAF-16 Flame Arrestor is bi-directional and can be installed either vertically or horizontally in a 4" line with companion 4" ANSI 150 lb. flat face flanges and standard gaskets that will withstand temperatures of 450 F degrees. The arrestor should be positioned so that the element is accessible for removal. The tension studs are supplied with jacking nuts on one half of the bolting circumference. Install the unit so that the jacking nuts (on the inside of the studs) are positioned on the opposite side from the direction that the element assembly will be removed. Models that have drain plugs are designed for horizontal installation and should be installed with the drain plugs aligned at the bottom of the unit. Models that have pressure taps are designed to allow pressure gauges to be installed on both sides of the flame cell assembly to determine blockage. The pressure taps should be aligned at the top to allow easy viewing of the gauges. The installation should only be performed when the system is not operating.

CAUTION

THIS FLAME ARRESTOR IS NOT DESIGNED TO ACCOMMODATE UNLIMITED BURNING. IF BURNING CAN OCCUR FOR A PERIOD EXCEEDING 5 MINUTES STARTING AT AMBIENT TEMPERATURE, IT IS RECOMMENDED THAT A TEMPERATURE ALARM AND SHUTDOWN SYSTEM BE INSTALLED.

B. Maintenance Instructions

It is important to keep the element openings clean to prevent loss of efficiency in absorbing heat. The element assembly should be removed and the elements cleaned to prevent the openings from becoming clogged with particulate matter. Clean the element with a suitable solvent, then blow dry using compressed air. Special care should be taken not to damage or dent the cell openings as this would hamper the effectiveness of the unit. Arrestor elements shall not be cleaned by rodding to remove blockages, as this practice could damage the elements and seriously impair the arrestor's performance. If the arrestor element cannot be cleaned satisfactorily, it must be replaced.

The cleaning interval should be governed by the amount and type of particulate in the system to which it is installed and must be determined by the user. To determine the maintenance interval the user should check the element in the first few months of operation to find how quickly particulate accumulates in the cells. After cleaning, the element should be thoroughly inspected for damage. If damaged, it must be replaced. **Under no circumstance should the element bank be disassembled from its shell for cleaning or replacement**. The element section must be replaced as a complete assembly.

C. Recommended Spare Parts

For installations that require frequent maintenance and minimum downtime it is recommended that the user purchase a spare element assembly and several spare element gaskets. The spare element assembly can be installed immediately and the dirty assembly can then be cleaned and be stored as a spare for the next maintenance interval. **Element gaskets should be replaced each time the cell assembly is loosened and removed to insure a gas tight seal.**

D. Element Assembly Disassembly & Reassembly Instructions

WARNING

Isolate gas supply and bring system to atmospheric pressure to prevent ignitable gas from flashing while performing maintenance.

1. Loosen all jacking (inside) nuts on tension studs between conical sections of the flame arrestor.

2. Tighten the inside jacking nuts on the tension studs forcing the two conical sections apart. When the two flange faces have separated, remove the tension studs that do not have inside jacking nuts, so that the element assembly can be removed.

WARNING

Element assemblies are heavy and will require the use of adequate equipment and manpower to prevent injury.

3. The inside jacking nuts are installed on all tension studs that facilitate jacking the unit apart. The inside jacking nuts are not installed on tension studs that are taken out, for ease of removal.

4. Thoroughly clean the gasket sealing faces being careful not to damage the sealing surface. For reassembly lightly grease one side of a new gasket and place it in the machined recess of each interior flange on the two conical sections.

5. Replace the flame element assembly with a new assembly or properly cleaned and inspected existing unit.

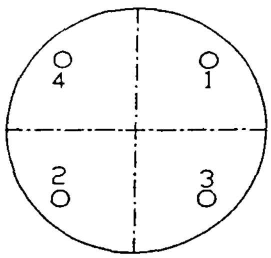
6. Loosen the jacking nuts on the tension rods until the flame cell assembly seats onto the gaskets.

7. Replace all tensioning studs and tighten the outer nuts hand tight only. Check to be sure that all the jacking nuts are completely loose and not making contact with the flange face.

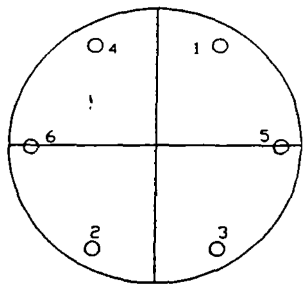
8. Torque the bolts in sequence as shown in the following instructions:

CAUTION

EXCESSIVE OR UNEVEN TORQUING CAN CAUSE PERMANENT DAMAGE TO GASKETS AND HOUSING.



7A



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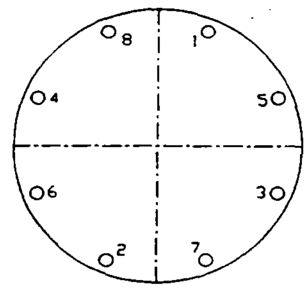

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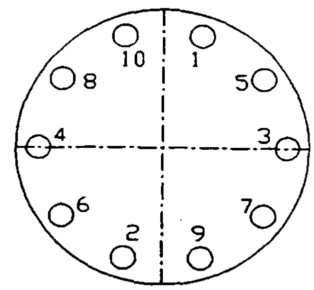

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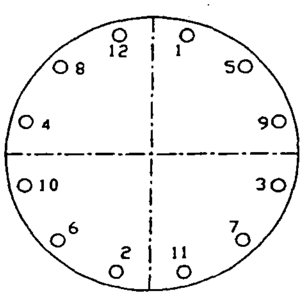

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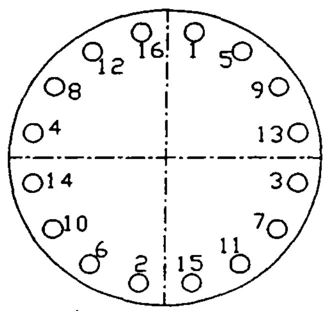

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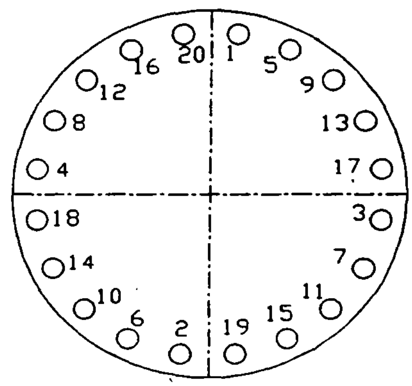


7G

SERIES 7 MODEL NO.	PATTERN	TORQUING STEPS (FT-LBS)			
		STEP 1	STEP 2	STEP 3	STEP 4
70401, 70802, 70803, 70804	7A	HAND TIGHT	10	25	30

Bolt Lubrication

Lubrication will affect required torque of clean fasteners in good condition more than any other factor. In fact, 90% of applied torque goes to overcome friction while only 10% actually stretches the bolt. The chart above assumes that only machine oil is used as a lubricant. Below is a list of several common lubricants and their affect on torque required to stretch bolts to 50% of their yield strength. Most are available from local bearing distributors.

Description	Coefficient of friction	Multiply torque value in chart by:
Machine Oil	f=.15	1.00
API SA2 Grease	f=.12	.80
Neverseez (Ni base)	f=.11	.73
Neverseez (Cu base)	f=.10	.67
Molykote G-n Paste	f=.06	.40

PRODUCT LIMITED WARRANTY

WARRANTY - Enardo Manufacturing Company warrants, to the extent stated herein, all products manufactured by it are free from original defects in workmanship or material for a period of twelve (12) months. Seller at its option will repair or replace any products returned to the factory in Tulsa, Oklahoma, transportation charges prepaid. Upon inspection, seller shall determine any defect in material and/or workmanship. There are no further warranties either express or implied in connection with the design, sale, merchantability or use of the items of sale and/or services. The rights and remedies of buyer hereunder

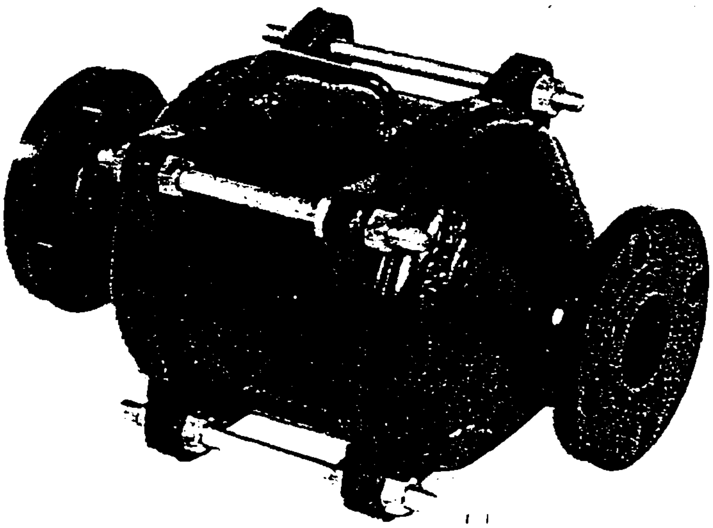
(i) Are exclusive and in substitution for and buyer hereby waives, all other warranties, guaranties, obligations, liabilities, rights and remedies, express or implied, arising by law or otherwise, including, but not limited to, the implied warranty of merchantability, any implied warranty of fitness and any obligation or liability of seller arising from tort or for loss of use, revenue or profit, or for incidental or consequential damages, and

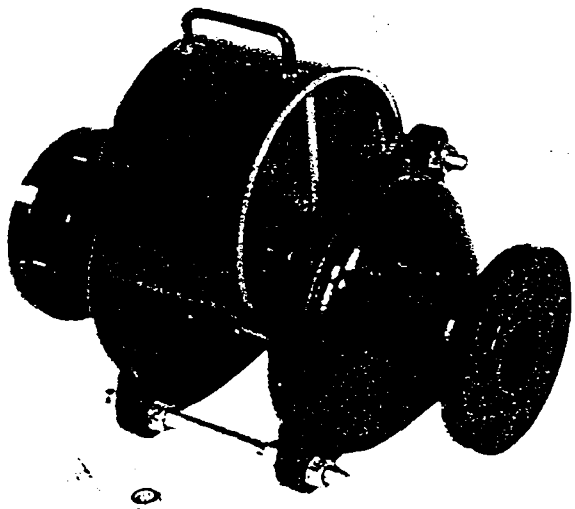
(ii) Shall not be modified except by written agreement, date even herewith or subsequent hereto, signed on behalf of buyer and Enardo by the respective duly authorized representatives.

Enardo Manufacturing Company
P O Box 266
Tulsa, OK 74101
(918) 835-6974 * FAX (918) 835-0044
(800) 336-2736 US and Canada

ENARDO CAST ALUMINUM

SERIES 7 FLAME ARRESTORS





ENARDO FLAME ARRESTORS are designed to stop the propagation of flame from ignited flammable liquid vapors with low flash points. They prevent flame propagation by absorbing and dissipating heat thereby reducing the temperature of the flame front preventing ignition behind the cell element. The Series 7 unit can be installed either vertically or horizontally and is available in aluminum, carbon steel or stainless steel. The cell element is available in aluminum or stainless steel. Special materials and protective coatings are available on request.

MAINTENANCE: Periodic inspection, maintenance and replacement is accomplished by expanding the jack screws and removing the appropriate bolts. The cell assembly can then be removed by the handle. Spare element sections can be inserted for minimum down time and ease of cleaning. Cleaning can be accomplished by dipping the entire cell assembly in an appropriate solvent. Care should be taken not to damage or dent the cell openings as such deformations hamper the flow through the cell. The gaskets should be inspected and replaced if necessary. An optional drain plug can be ordered that releases fluid when the arrestor is in a horizontal position.

SPECIFICATIONS:

Connections: 1" through 36" in 150 lb flat faced and raised face flanges or threaded connections.

Housing materials: Aluminum

Cell materials: Aluminum or Stainless Steel.

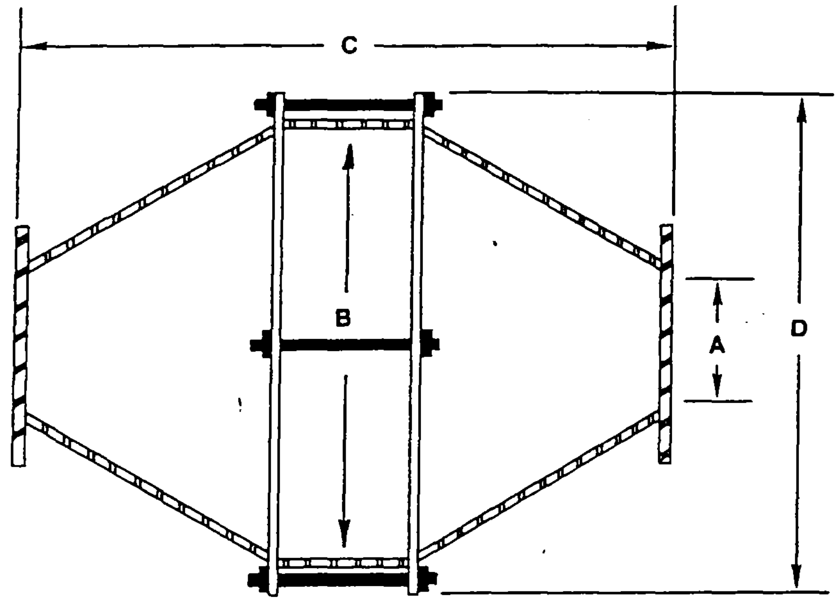
Gas Group: N.E.C. D, C & B

ORDERING INFORMATION:

1. Connection size.
2. Maximum rate of flow.
3. Maximum pressure rating.
4. Maximum allowable pressure drop.
5. Housing material.
6. Cell material and gas group.
7. Protective coatings.
8. Special options.

ENARDO MANUFACTURING CO.

Post Office Box 266
Tulsa, Oklahoma 74101
(918) 835-6974
(800) 322-1155 (Outside Oklahoma)
FAX (918) 835-0044



A	B		C*	D	
CONNECTION SIZE	HOUSING SIZE		OVERALL LENGTH	OUTSIDE DIAMETER	
2"	8"		16-½"	11"	
3"	8"		16-½"	11"	
4"	8"		16-½"	11"	
6" ‡	10"	12"	21-½"	13"	15"
8" ‡	14"	16"	25-½"	17"	19"
10"	20"		30-½"	24"	

(Dimensions shown are for reference)

* These dimensions are for cast aluminum models only. Steel models should refer to sheet no. FA-1F & FA-2F.

‡ Variations of models due to two housing sizes per connection size.

KEY TO ENARDO SERIES 7 ALUMINUM FLAME ARRESTOR MODEL NUMBER

☐ [7] ☐☐ ☐☐ / ☐ – ☐ ☐ ☐ – ☐☐

- Blank= Concentric, E= Eccentric
- Series 7
- **Housing Size**
- **Connection Size**
- **NEC Gas Group**: B= Group "B", C= Group "C", D= Group "D", M= Methane
- **Housing Material**: A= Aluminum
- **Cell Material**: A= Aluminum, 4= 304 S.S., 6= 316 S.S., E= Exotic Material
- **Connection Type**: F= Flat Faced Flange, R= Raised Face Flange
- **Options**: 1= Drain Plugs, 2= Temperature Probe Taps, 3= Pressure Taps, 4= Miscellaneous Fittings, 5= Protective Coatings, 6= Special Features

MPLE: [ ] [7] [2] [0] [1] [0] / [M] – [A] [4] [F] – [1] [2]

Indicates a Concentric Series 7 Inline Flame Arrestor with a 20" aluminum housing, 10" flat faced flange connections and 304 stainless steel flame cell element for methane gas. It also has additional options of drain plugs and temperature probe taps.

 Revised (5/96)

Instruction Manual

UT15/UT14
Digital Indicating Controller

CONTENTS

YOKOGAWA ◆
Yokogawa Electric Corporation

IM 5B4A7-03E
2nd Edition

The revision record and the notes for the enhancement of the performance and function is listed on the last page of this manual.

1. WHEN YOU RECEIVE THIS INSTRUMENT...

Thank you for purchasing the UT15 or UT14 digital indicating controller.

Please read this "Instruction Manual" carefully, and use the instrument correctly.

Diagrams in this "Instruction Manual" mainly show the UT15, but the handling of the UT14 is exactly the same.

● Regarding Force Majeure

Yokogawa Electric Corporation assumes no liability to any party for any loss or damage, direct or indirect, caused by the use or any unpredictable defect of the product.

Notes on Handling the UT15 and UT14

Cleaning of the front panel, key switches, etc., should be limited to wiping lightly with a dry cloth.

Do not use any solvents such as alcohol, benzene, etc.

■ Documentation Conventions

The symbolic conventions below are used in this manual.

⚠CAUTION: This marking on the product indicates that the operation must refer to an explanation in the instruction manual in order to avoid damage to the instrument.

⚠WARNING: This marking on the product indicates that the operator must exercise special care to avoid electric shock or other dangers that may result in injury or the loss of life.

1. 1 Checking Accessory Items

Check that all of the following items are present.

- UT15 main unit or UT14 main unit .... 1 unit
- Bracket (installation hardware) .... 2 pcs.
- Unit seals (labels) .... 1 sheet
- Instruction Manual (main text) .... 1 copy
- Instruction Manual (communications volume) .... 1 copy*

* Included only when option /RS422 is specified.

1. 2 Verifying Product Specifications

Verify that the product delivered agrees with the model code ordered.

Model/Option Code Table

Model	Suffix code		Description
UT15	....		Digital indicating controller
Style code		*A	Style A
Option codes		/RET	Measured value retransmission output
		/RS422	RS-422A communication interface

Model	Suffix code	Description
UT14	....	Digital indicating controller
Style code	*A	Style A
Option codes	There are no option suffix codes for the UT14.	

1. 3 Verifying Measurement Input Type and Control Output Type

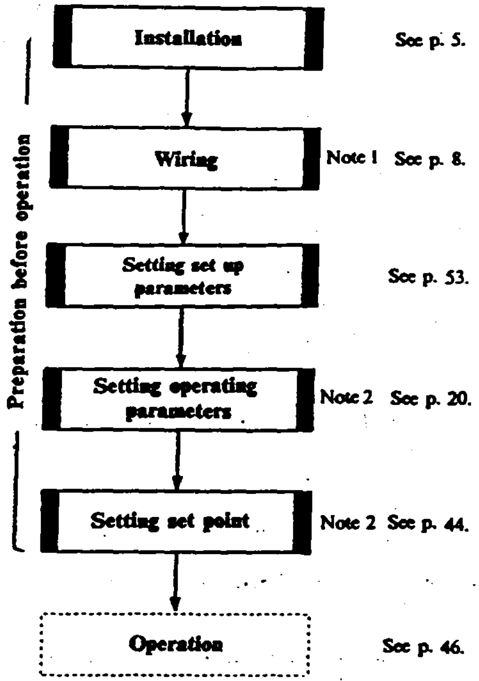
○ Unless otherwise specified, the UT15 and UT14 are shipped from the factory set up as follows:
  Measurement input range code: 0 (thermocouple type K, −200 to 1200°C)
  Control output type code: 0 (relay output)

○ The controllers are shipped from the factory with the control action set up for reverse action.

○ If you need to change any of these settings to use this instrument, see Appendix 1, Input, Output, and Control Action Change Procedures (p.53).

2. BEFORE BEGINNING OPERATION

Prepare for use according to the flow chart below.



Note 1: This instrument itself has no power switch. It will begin to operate and generate a control output as soon as power is supplied to it. We recommend that the device to be controlled not be connected until immediately before operation is to begin.

Note 2: The parameters and setpoint (SP) for this instrument will be set when shipped from the factory as described in Appendix 3 and 4.

3. INSTALLATION

3. 1 Installation Location

Install the instrument in a location that meets the following criteria.

(1) Little or no mechanical vibration.
(2) No corrosive gases.
(3) Minimal temperature fluctuation, and near normal temperature (32 °F to 122°F)
(4) Not directly subject to radiant heat.
(5) Not subject to strong electromagnetic fields.
(6) No direct exposure to water.

3. 2 Installation Procedure

(1) Insert the instrument from the front of the panel.
(2) To fasten the instrument to the panel, use the accessory installation brackets provided. Take care not to overtighten the bracket screws when mounting.

CAUTION

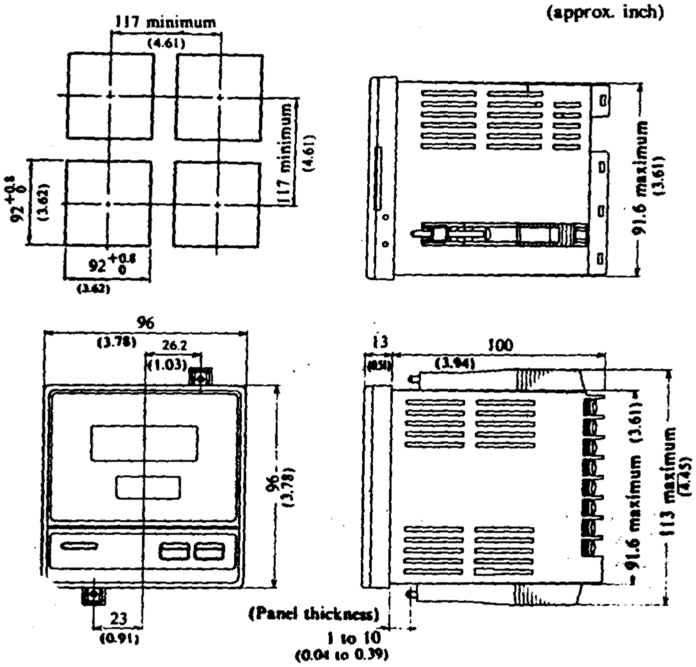
CAUTION: WHEN MOUNTING ON OR OVER A COMBUSTIBLE SURFACE, A PLATE OF AT LEAST 1.43mm GALVANIZED OR 1.6mm UNCOATED STEEL EXTENDED AT LEAST 150mm BEYOND THE EQUIPMENT ON ALL SIDES MUST BE INSTALLED and

AVERTISSEMENT: LORSQUE L'APPAREIL EST INSTALLÉ SUR OU AU-DESSUS D'UNE SURFACE COMBUSTIBLE, ON DOIT PRÉVOIR UNE PLAQUE D'ACIER GALVANISÉ D'AU MOINS 1.43mm OU UNE PLAQUE D'ACIER SANS REVÊTEMENT DE 1.6mm SE PROLONGEANT SUR AU MOINS 150mm TOUT AUTOUR DE L'APPAREIL.

Outside Dimensions and Panel Cutout Dimensions

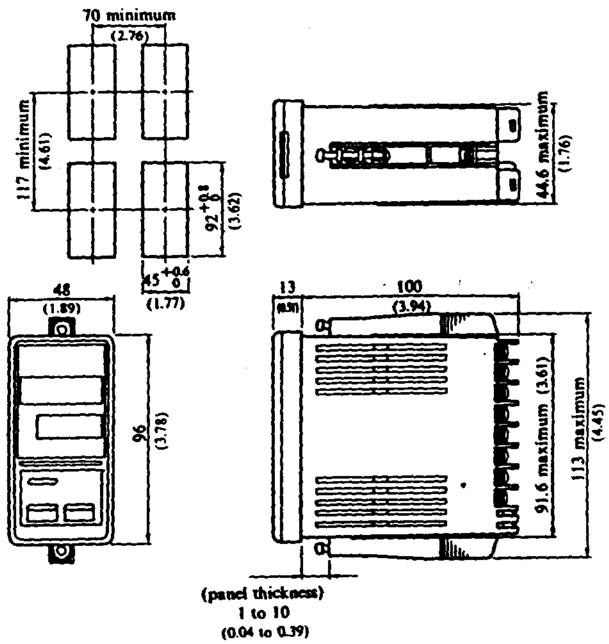
UT15

Unit: mm
(approx. inch)



UT14

Unit: mm
(approx. inch)



4. WIRING

1 Wiring Procedure

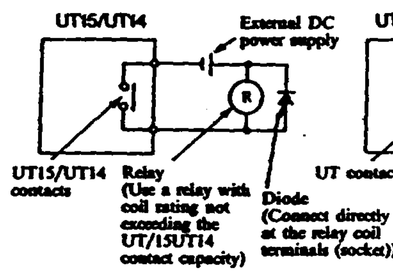
When wiring, see Section 4. 3, "Terminal Wiring Diagrams," and observe the following precautions.

(1) In the case of thermocouple input, use the proper thermocouple extension wire type (compensating leads).
(2) For RTD input, use wiring having low conductor resistance, and no significant differences in resistance among the three conductors.
(3) For power supply wiring, use a cable or wiring with characteristics equal to or better than 600 V vinyl insulated wire (JIS C3307). If necessary, insert a noise filter in the power supply circuit.
(4) The ground conductor should have at least a 2 mm^2 crosssectional area, with resistance to ground not exceeding 100 Ω maximum.
(5) Plan the input circuit wiring so as to avoid noise pickup.
  (a) The input circuit wiring should be kept as far away as possible from power and ground circuits.
  (b) Use of shielded wire is effective against noise due to electrostatic induction. If necessary, connect the shield to the ground terminal of the UT15/UT14. (Be careful that this does not result in a two-point ground.)
  (c) Use of conductor pairs twisted with a short and constant spacing between twists is relatively effective against noise due to electromagnetic induction.
(6) For connecting the wiring to the terminals, we recommend use of crimp terminal lugs (3.5 mm screw) with insulated sleeves.

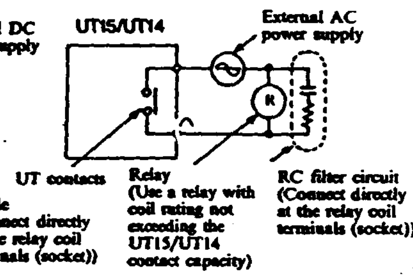
4. 2 Cautions When Wiring

(1) There is no fuse or power supply switch in this instrument. If required, these must be provided separately.
For fusing, use time-lag fuses with a rated voltage of 250V, and a rated current of 1A.
(2) If a load exceeds a relay output contact rating (control output: 250 V, 3 A AC resistive load; alarm output 250 V AC, 1A resistive load), use an auxiliary relay to turn the load on and off.
(3) If using an inductive load such as an auxiliary relay on a relay contact output, connect a diode (for DC) or an RC filter (for AC) in parallel as a surge suppressor circuit to suppress sparking.

● **For DC relay**

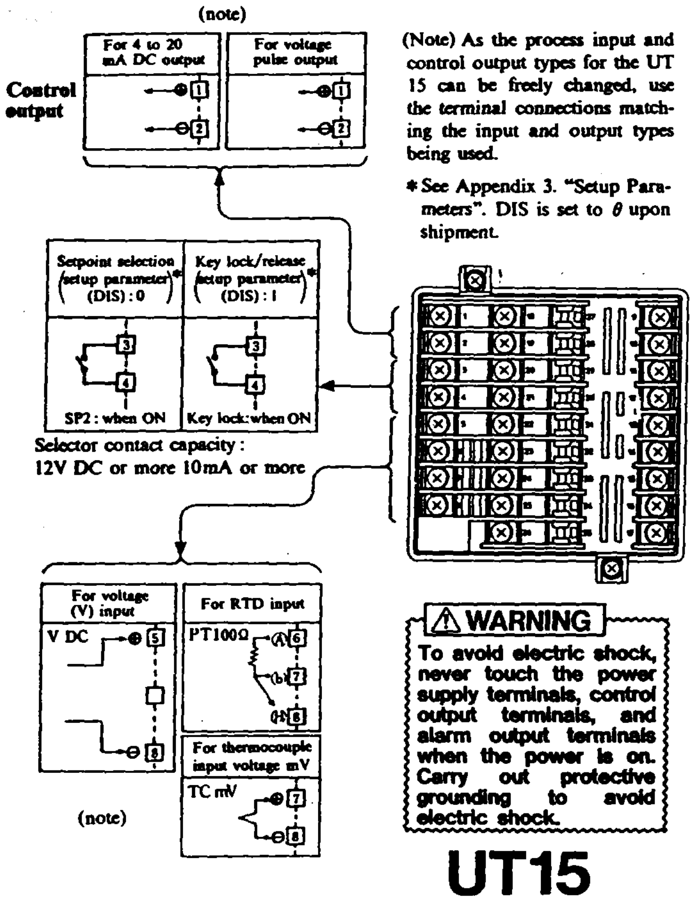


● **For AC relay**



4. 3 Terminal Wiring Diagram

3. 1 UT15 Terminal Wiring Diagram

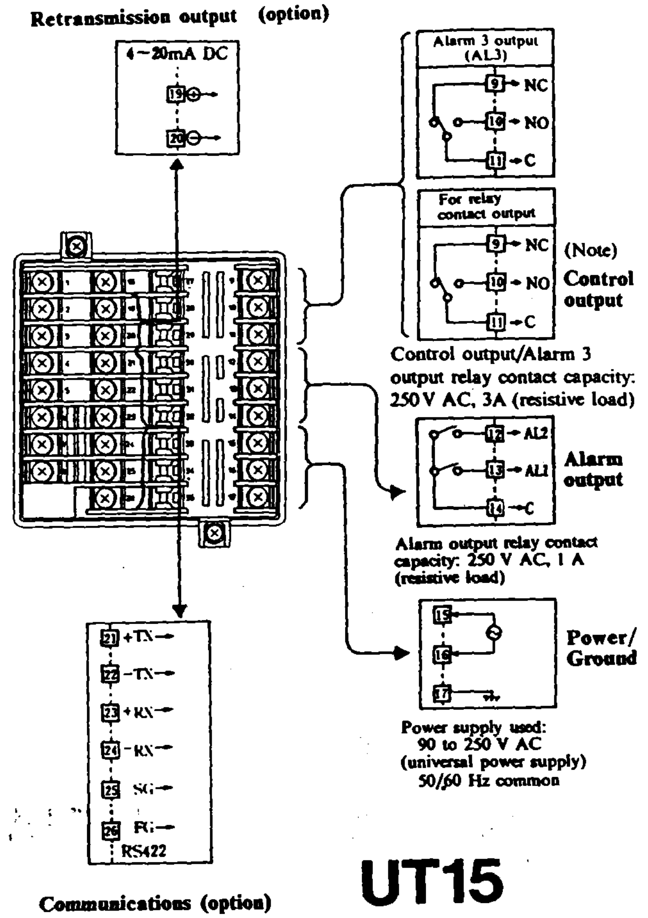


(Note) As the process input and control output types for the UT 15 can be freely changed, use the terminal connections matching the input and output types being used.

* See Appendix 3. "Setup Parameters". DIS is set to 0 upon shipment.

⚠ WARNING

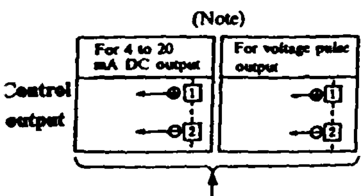
To avoid electric shock, never touch the power supply terminals, control output terminals, and alarm output terminals when the power is on. Carry out protective grounding to avoid electric shock.

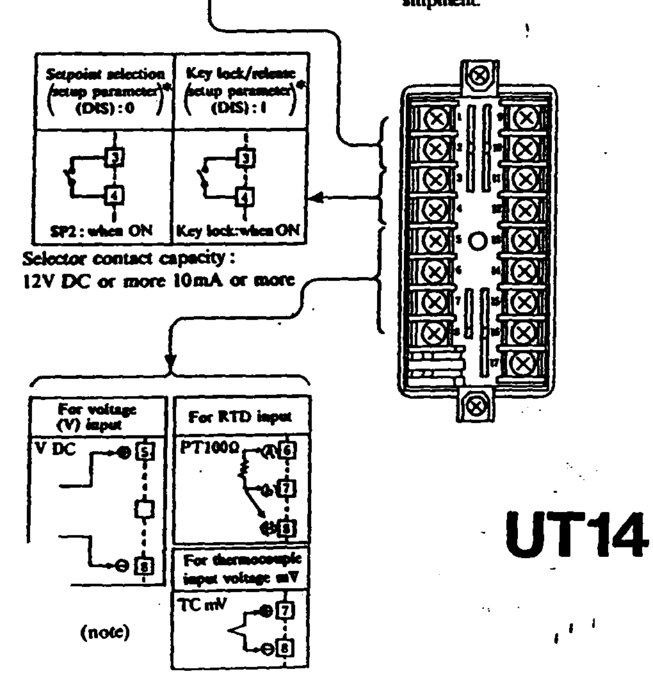


4 UT14 Terminal Wiring Diagram

(Note) As the measurement input and control output type for the UT14 can be freely changed, use the terminal connections matching the input and output types being used.

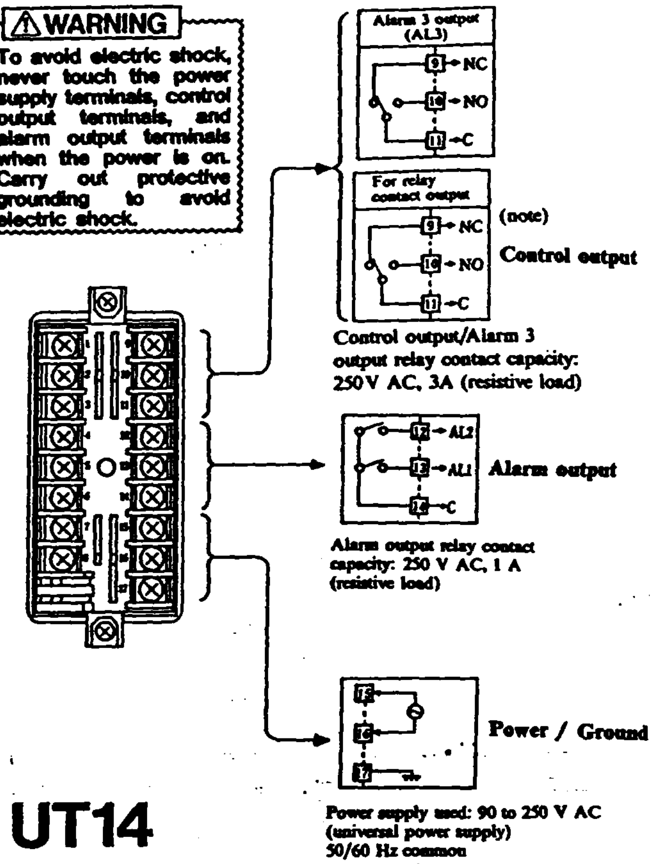
* See Appendix 3. "Setup Parameters". DIS set to θ upon shipment.



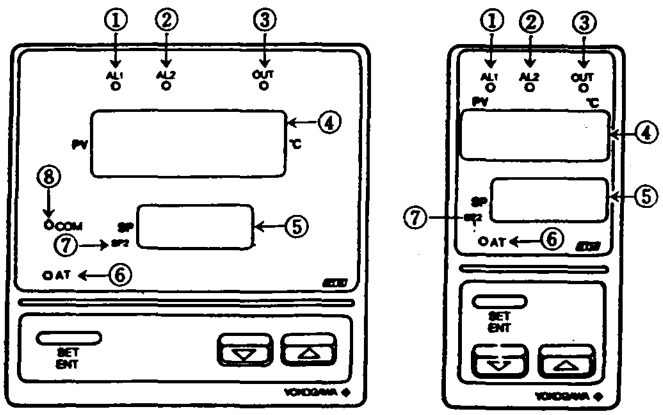


⚠WARNING

To avoid electric shock, never touch the power supply terminals, control output terminals, and alarm output terminals when the power is on. Carry out protective grounding to avoid electric shock.



. FRONT PANEL DISPLAY AND USE



Key	Function
SET ENT (Set/entry key)	• Used to switch between the normal display panel (measured variable display) and operating parameter setting display panel. (Pressing and holding this key for 3 seconds or more switches between the two displays.) • Calls up the individual operating parameters one by one in sequence. • Registers (enters) numeric values and changes.
▽ △ (Numeric value keys)	Used to change the displayed value of the set point or any operating parameter. The ▽ (down) key decreases the value, and the △ (up) key increases the value. Although when one of these keys is pressed the numeric value increments or decrements in units of one, holding the key continuously causes the rate of change to increase.

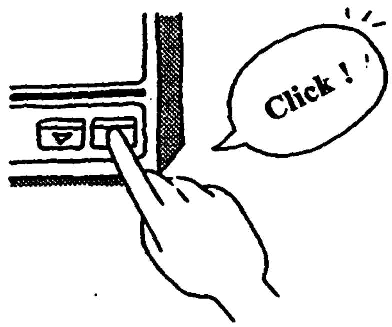
No.	Display	Function
①	AL1 O (Alarm 1 lamp)	Lights when alarm 1 is occuring.
②	AL2 O (Alarm 2 lamp)	Lights when alarm 2 is occuring.
③	OUT O (Control output monitor)	Monitors the control output. ● For relay or voltage pulse output, lights with output "ON". ● For 4 to 20 mA output, flash pattern changes according to percent output.
④	PV 8888 ℃ (Measured-value display)	● Displays the measured value (PV). ● During operating parameter setting, displays the parameter symbol.
⑤	SP 8888 (Set-point value display)	● Displays the set-point value (either main or 2nd) currently in use. (During operating parameter setting, displays the parameter numeric value.)
⑥	O AT (Auto tuning execution indicator lamp)	Flashes while auto tuning is occuring.
⑦	SP2 2nd set point in use indicator lamp)	Lights during operations with the "2nd" set point. Flashes during MAN mode regardless of whether setpoint SP1 or SP2 is selected.
⑧ *	O COM (Communication indicator lamp)	● Lights while communications (RS-422A) are in progress. ● Flashes when there is a communication error (parity error, framing error).

* The COM lamp is provided on the UT15 only.

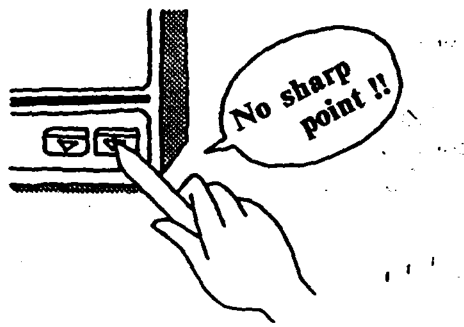
6. OPERATIONS

⚠ Notes on Key Operation

① The keys on this instrument have been designed with tactile feedback, and will click when pressed. Press firmly with your finger until you feel this click.

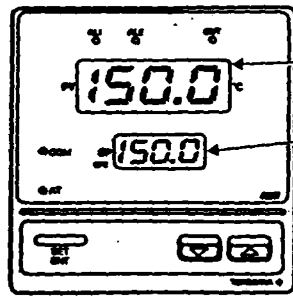


② Never use a sharp point to press the keys, as this can cause failure of the key.



6. 1 Normal Display Panel and Operating Parameter Setting Display Panel

The UT15 and UT14 has two major display modes. Switching between these display panels is done by holding the SET/ENT key depressed for three or more seconds.



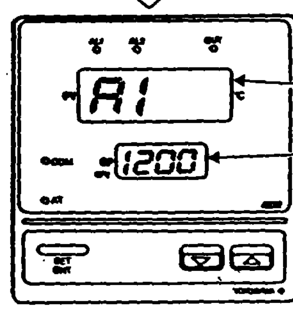
Normal display panel

The measured value is displayed in the measured value display area.

The set point value is displayed in the set point display area.

When this display panel is presented the set-point can be changed.

SET/ENT Push this key and hold for three seconds or more to alternate between these displays



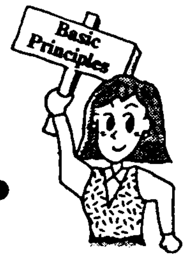
Operating Parameter setting display panel

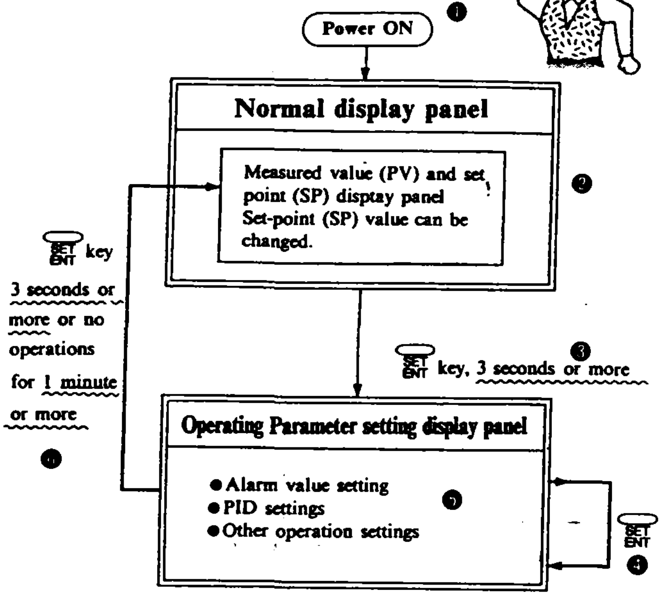
The parameter symbol is displayed in the measured-value display area.

The parameter setting is displayed in the set-point value display area.

When this display panel is on display the operating parameters can be changed and entered.

6. 2 Basic Principles of Key Operation





1. When power is applied to the UT15 or UT14 it displays the normal display panel.
   (After power is turned ON, the model, input range code, and output type code are displayed in the measured-value display area for approximately 2 seconds before the normal display panel appears.)
2. The normal panel displays the measured value (PV) and the set-point value (SP).
   The set point can be changed by pressing the ▽ or △ key; this will cause the decimal point to begin flashing.
   The new value will take effect when entered by pressing the SET/ENT key.
3. Pressing the SET/ENT key continuously for 3 seconds or more while the normal display panel is shown switches the display to the parameter setting display.
4. Subsequent depressions of the SET/ENT key (for less than 3 seconds) step the display sequentially through the individual operating parameters.
5. The ▽ and △ keys can be used to change the settings (displayed values) of the individual operating parameters.
   (The decimal point will be flashing while a change to one of these numeric values is in progress.) After changing a setting, press the SET/ENT key to enter it.
6. When either of the following is done while the operating parameter setting display is present the display returns to the operating display panel.
   - SET/ENT key is pressed continuously for 3 seconds or more.
   - No operation is performed for 1 minute or more.

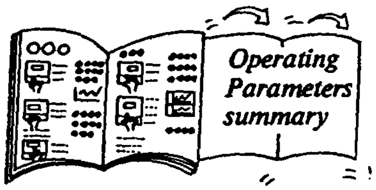
6. 3 Key Lock

To protect important data, the UT15 and UT14 have a key lock function No key operations can be performed when the key lock is engaged.

The procedure for placeing the controller in the key lock state is described in Appendix 2 (p.57).

7 OPERATING PARAMETER SETTING

. section describes procedures for setting the operating parameters. When you are entering these settings you will find it convenient to open Appendix 4. "Operating Parameters (Including Set Points) Summary" (P. 64 and 65) as shown below.

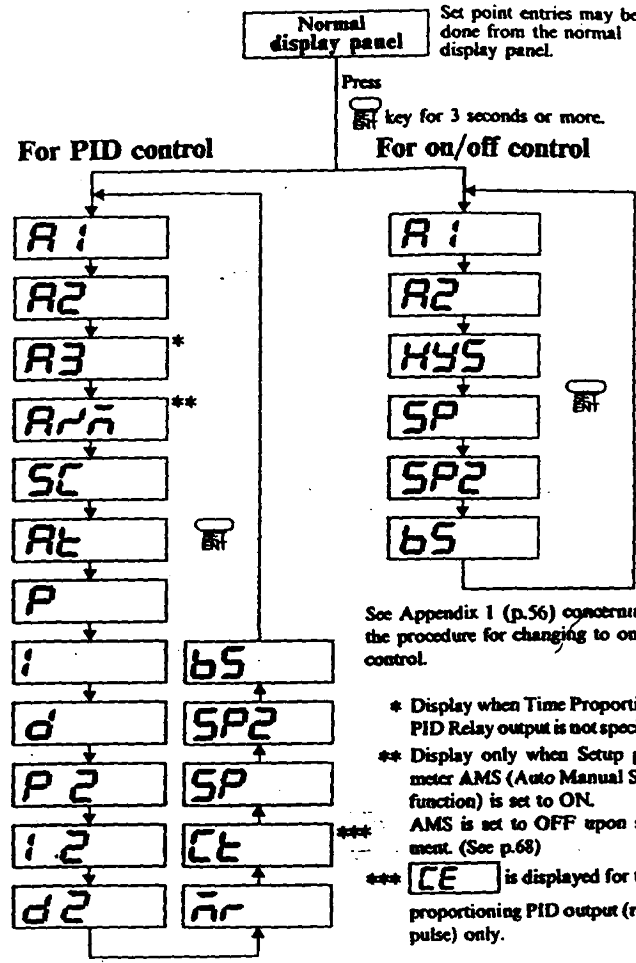


Notes on Operating Parameter Setting

Note 1: To enter these settings, press the SET/ENT key for three seconds or more continuously from the normal display panel, as described in Section 6. 2, "Basic Principles of Key Operation", to call up the operating parameter setting display panel.

Note 2: When on/off control is selected, the types of operating parameter setting selections (symbol displayed) that appear differ depending to the control output chosen (see Appendix 1). (See figure at right.)

Note 3: • If the entry of one operating parameter has been completed and no additional operating parameter entries are required, press the SET/ENT key for three seconds or more to return to the normal display panel. (If no key operations are performed for 1 minute or more, the display automatically returns to the operating display panel.)
• If other operating parameter entries are required, press the SET/ENT key once for each parameter to step to the correct item display for the required parameter. When setting individual parameters see the detailed setting procedures (p.22 through p.43.).



See Appendix 1 (p.56) concerning the procedure for changing to on/off control.

* Display when Time Proportional PID Relay output is not specified.

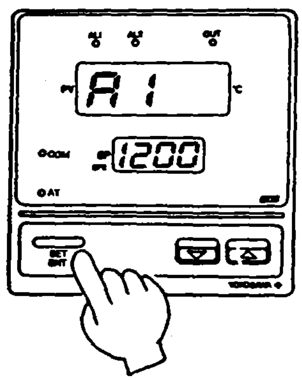
** Display only when Setup parameter AMS (Auto Manual Select function) is set to ON. AMS is set to OFF upon shipment. (See p.68)

*** CE is displayed for time-proportioning PID output (relay, pulse) only.

Alarm Setting Procedure

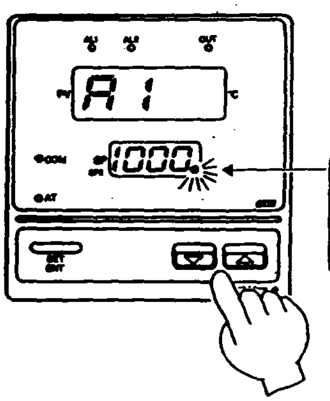
7. 1. 1 Alarm 1 (A1) Setting Procedure (see appendix 3 for selecting Alarm type), comes from factory as High Limit Alarm.

①



From the normal display panel (measured-value display), press the SET/ENT key for 3 seconds or more continuously.
(The display should appear as at left. Verify that A1 is displayed.)

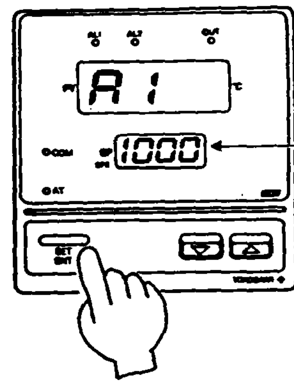
②



Using the △ and ▽ keys, set the alarm 1 setting to the required value.

[The decimal point will flash. If you return to the value in effect before changes were made, the decimal point will light or disappear. (when integral number)

③

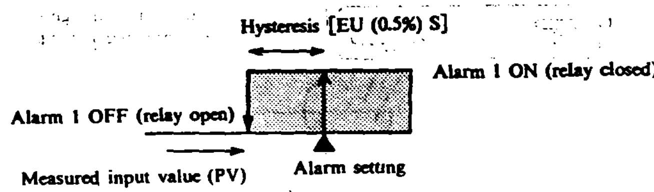


Press the SET/ENT key once.
This completes the setting.
(Note)

[The decimal point lights or disappears.(when integral number)

Note: See "Note 3" of the "Notes on operating Parameter Setting" (p. 20).

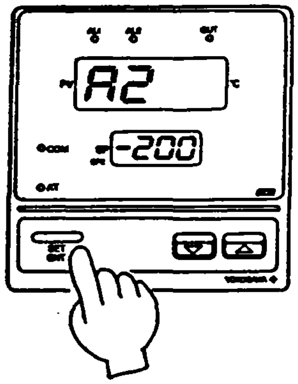
○ **Alarm 1 (Shipped as high limit N.O. Alarm) (A1)**
If the measured input value (PV) exceeds the alarm setting, the alarm turns ON, and the alarm relay closes. The alarm is cancelled when the PV drops below the alarm setting by the alarm hysteresis width.



7. 1. 2 Alarm 2 (A2) Setting Procedure

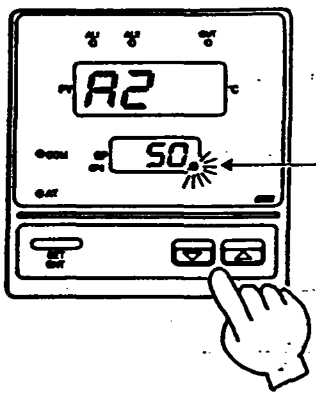
See Appendix 3 for selecting alarm action.
Shipped from factory as low limit alarm.

①



- From the normal display panel (measured-value display), press the SET/ENT key continuously for three seconds or more to display the alarm 1 setting display panel.
- Then, press and release the SET/ENT key once more.
  (The display should appear as at left. Verify that A2 is displayed.)

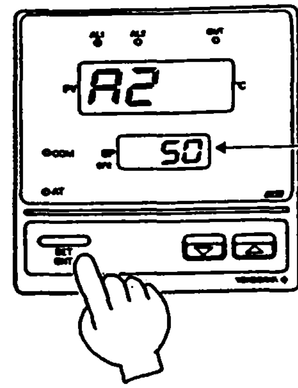
②



Using the △ and ▽ keys, set the alarm 2 setting to the required value.

The decimal point will flash. If you return to the value in effect before changes were made, the decimal point will light or disappear. (when integral number)

③



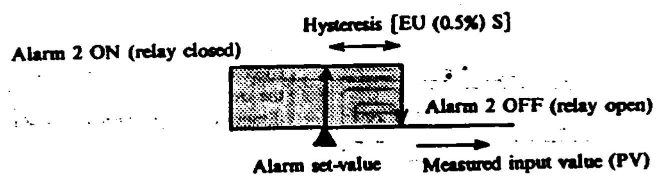
Press the SET/ENT key once.
This completes the setting.
(Note)

The decimal point lights or disappears.(when integral number)

Note: See "Note 3" of the "Notes on Operating Parameter Setting" (p.20).

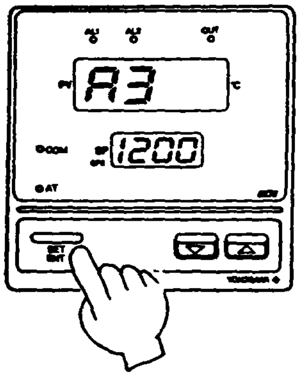
○ Alarm 2 (shipped as low limit N.O. Alarm) (A2)

If the measured input value (PV) falls below the alarm setpoint, the alarm is turned ON, and the alarm relay closes. The alarm is cancelled when the PV rises above the alarm set-value by the alarm hysteresis width.



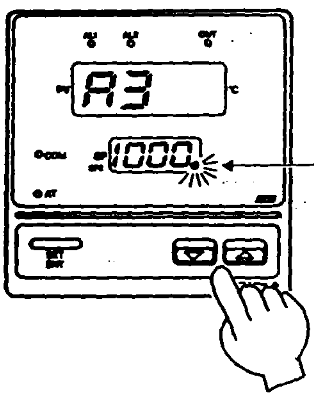
7. .. 3 Alarm 3 (A3) Setting Procedure (see appendix 3 for selecting Alarm type), comes from factory as High Limit Alarm.(Display When Time Proportional PID relay output is not specified.)

①



From the normal display panel (measured-value display), press the SET/ENT key for 3 seconds or more continuously.
(The display should appear as at left. Verify that A3 is displayed.)

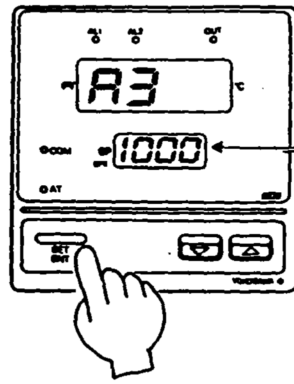
②



Using the △ and ▽ keys, set the alarm 3 setting to the required value.

The decimal point will flash. If you return to the value in effect before changes were made, the decimal point will light or disappear. (when integral number)

③

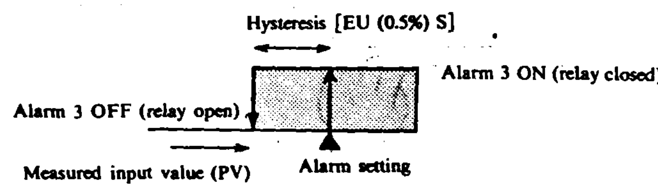


Press the SET/ENT key once.
This completes the setting.
(Note)

The decimal point lights or disappears.(when integral number)

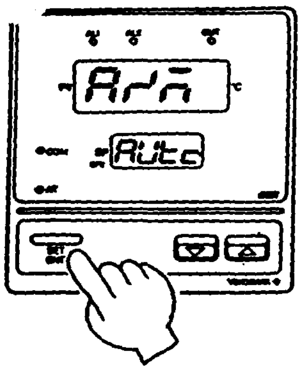
Note: See "Note 3" of the "Notes on operating Parameter Setting" (p. 20).

○ Alarm 3 (Shipped as high limit N.O. Alarm) (A3)
If the measured input value (PV) exceeds the alarm setting, the alarm turns ON, and the alarm relay closes. The alarm is cancelled when the PV drops below the alarm setting by the alarm hysteresis width.

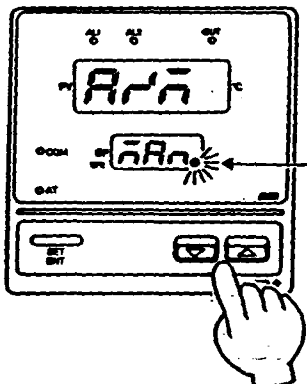


7.2 AUTO/MAN Selection Procedure

Note: • This parameter [A/M] displays only when Setup parameter AMS (Auto/Manual select function) is set to ON. AMS is set to OFF upon shipment. (See Appendix 3. p.68)
Cannot be selected when on/off control is in effect.

① 

From the operating parameter setting display panel, press the SET/ENT key several times to come to the display in the figure at left.
(Verify that [A/M] is displayed.)

② 

Use the [▲] and [▼] keys to display either "AUTO" or "MAN" in the lower indicator.

The decimal point begins flashing. If you return to the value in effect before the change, it disappears.

③ Press the SET/ENT key once. This completes the setting. (Note)
he decimal point disappears.

Note: See "Note 3" of the "Notes on Parameter Setting" (p. 20)

○ **Details on AUTO/MAN Functions**

① Lamp SP2 flashes during MAN mode regardless of whether setpoint SP or SP2 is selected.

② Even if the power is turned off during AUTO or MAN mode, the operation restarts from the status immediately before turning off the power, when the power is turned on again.

③ When the power is on, outputs in MAN mode are as follows:
  a. When EOUT=0 and OL > 0.0 : OL
  b. When EOUT=0 and OL ≤ 0.0 : 0.0%
  c. When EOUT=1 and OH < 100.0 : OH
  d. When EOUT=1 and OH ≥ 100.0 : 100.0%

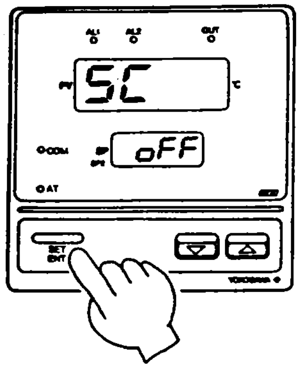
Setup parameters:
  EOUT= output code when error occurs
  OH = Output high limit
  OL = Output low limit

In AUTO mode, the controller starts operating with the condition under which it was operating at power-off.

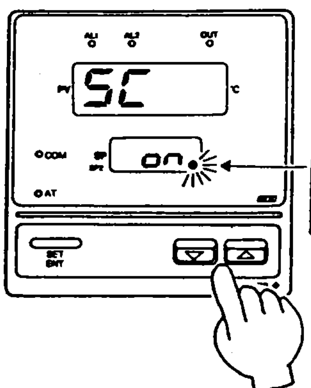
④ Whether parameter A/M is displayed can be selected by selecting setting range ON/OFF in the setup parameter AMS.
(See Appendix 3. p.68)

7. 3 "Super" Function ON/OFF Selection Procedure

Note: • Cannot be selected when on/off control is in effect.
• "Super" takes effect only with PID control. It has no effect with P, PI, or PD control.



From the operating parameter setting display panel, press the SET/ENT key several times to come to the display in the figure at left.
(Verify that SC is displayed.)

② 

Use the △ and ▽ keys to display either "ON" or "OFF in the lower indicator.

The decimal point begins flashing. If you return to the value in effect before the change, it disappears.

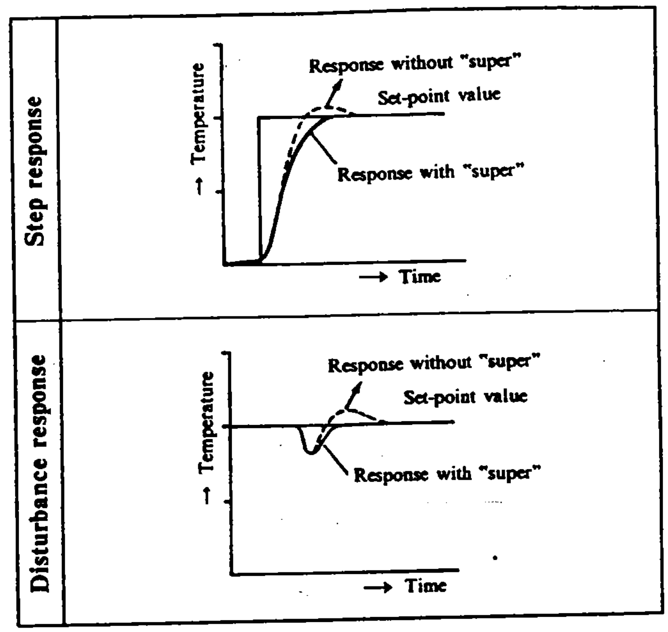
③ Press the SET/ENT key once. This completes the setting. (Note)
The decimal point disappears.

Note: See "Note 3" of the "Notes on Parameter Setting" (p. 20)

○ **Effect of "Super"**

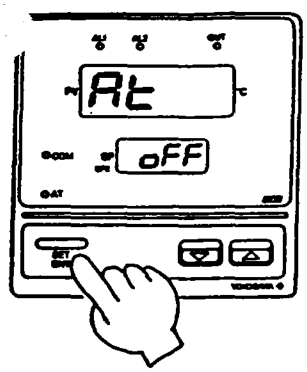
This function suppress overshoot.
It is particularly effective.
- To suppress overshoot.
- To shorten rise time.
- Where there are frequent load changes. (process upsets)
- During setpoint changes.

Super controls overshoot by using a fuzzy logic inference algorithm.

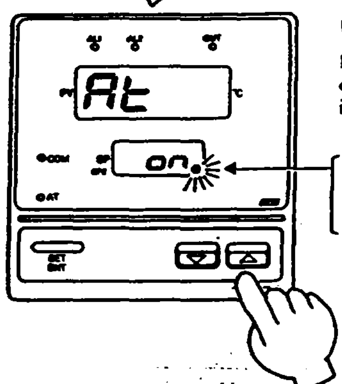


7. 4 Auto Tuning Start (ON)/Stop (OFF) Procedure

Note: Auto tuning cannot be started when on/off control is in effect.



From the operating parameter setting display panel, press the SET/ENT key several times to come to the display in the figure at left.
(Verify that At is displayed.)

② 

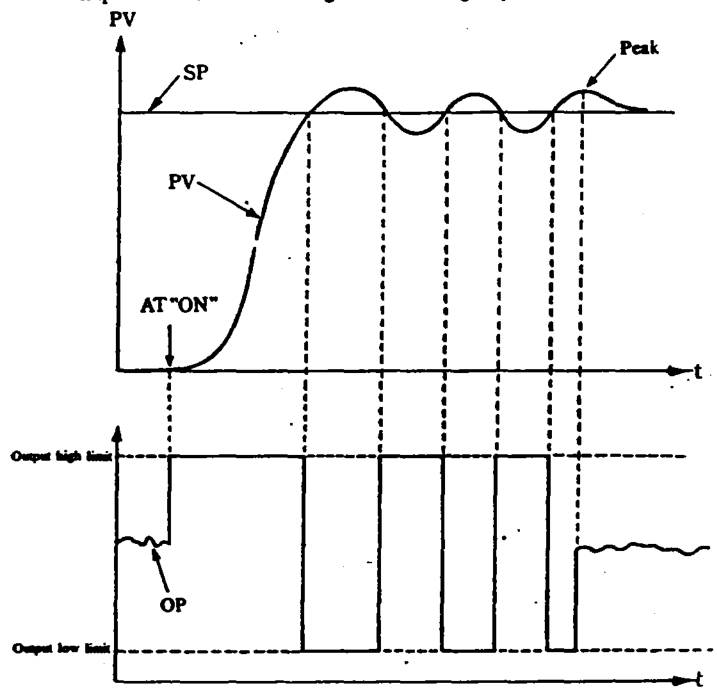
Use the △ and ▽ keys to display either "ON" or "OFF" in the lower indicator.

The decimal point begins flashing. If you return to the value in effect before the change, it disappears.

③ Press the SET/ENT key once. This copletes the setting. (Note)
The decimal point disappears.
·e O AT lamp will be flashing while auto tuning is being executed.
: See "Note 3" of the "Notes on Operating Parameter Setting" (p. 20).

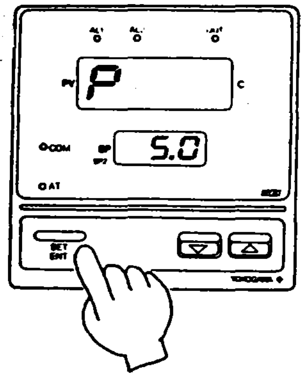
UT15/UT14 Auto Tuning Procedure

At the time that auto tuning is started (AT = "ON"), the control output for the UT15 or UT14 will go to output high limit. The condition output (OP) output high limit is then maintained until the measured value (PV) reaches the set point (SP). Subsequently, whenever PV>SP, the OP is sent to output low limit. As shown in the figure below, the OP is sent to output low limit. As shown in the figure below, the OP value is then caused to repeat this alternation between output high and output low according to the relative magnitude of PV and SP three times, and the PID constants are determined automatically by the response of the control object. Consider the product and possible implications before initiating the autotuning sequence.

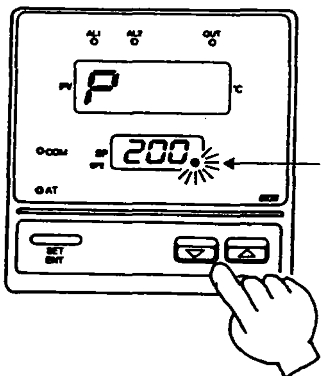


7. 5 Proportional Band (P) Setting Procedure

Note: The proportional band setting display is not available when on/off control is in effect.



From the operating parameter setting display panel, press the SET ENT key several times to come to the display in the figure at left.
(Verify that P is displayed.)

② 

Use the △ and ▽ keys to set the proportional band to the required value.

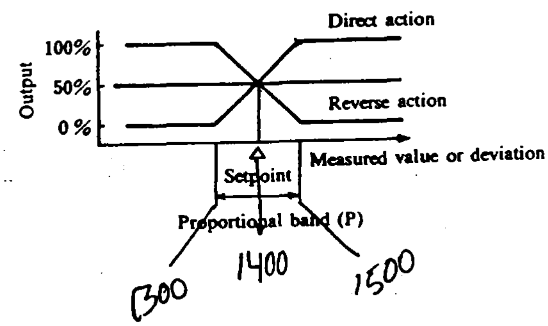
The decimal point begins flashing. If you return to the value in effect before the change, it remains lit continuously.

③ Press the SET ENT key once. This completes the setting. (Note)
The decimal point remains lit continuously.

e: See "Note 3" of the "Notes on Operating Parameter Setting" (p. 20).

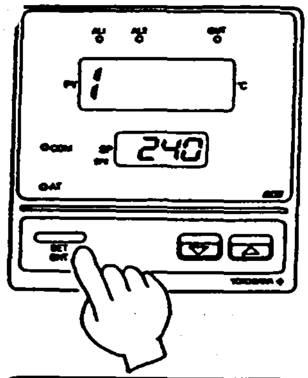
○ **What is Proportional Band (P)?**

The control algorithm that generates a linear control output proportional to the deviation is called "proportional action" (or, "P" action). In proportional action the amount of change in the measured value (or deviation) is expressed in percent of span that is required to cause the control output to change from 0 to 100% is called the proportional band.
In general the output will be 50% when the measured value and set point are exactly the same, But this may be adjusted using manual reset. Proportional action makes it possible to eliminate the output and PV fluctuations that are a shortcoming of on/off control.



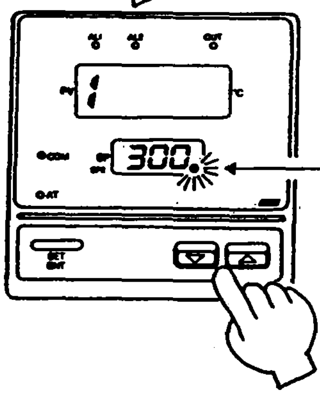
7. 6 Integral Time (I) Setting Procedure

Note: The integral time setting display is not shown when on/off control is selected.



From the operating parameter setting display, press the SET/ENT key several times to come to the display in the figure at left. (Verify that [I] is displayed.)

②



Use the [△] and [▽] keys to set the integral time to the required value.

The decimal point begins flashing. If you return to the value in effect before the change, it disappears.

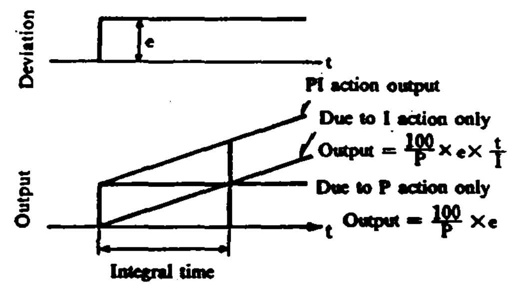
③ Press the SET/ENT key once. This completes the setting. (Note)
: decimal point disappears.

Note: See "Note 3" of the "Notes on Operating Parameter Setting" (p.20).

o **What is Integral Time (I)?**

With P action the measured value will not necessarily become equal to the set point, and a deviation will usually be present. The control algorithm that applies changes in *output* as long as a deviation exists, so as to bring the deviation to zero, is called "integral action" ("I" action).

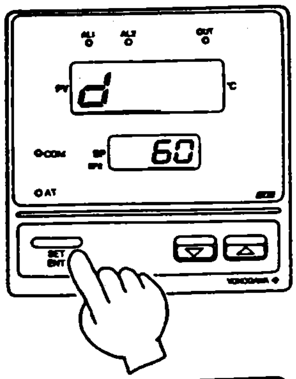
When integral action is used, the parameter that determines how fast the output will change in correspondence to some amount of deviation is referred to as the integral time, and the shorter the integral time, the stronger the integral action (the greater the output rate-of-change). I action is usually used together with P action as PI action, and the integral time (I) is the time required, after application of a step input, for the output change due only to I action to become equal to that due only to P action.



7. 7 Derivative Time (D) Setting Procedure

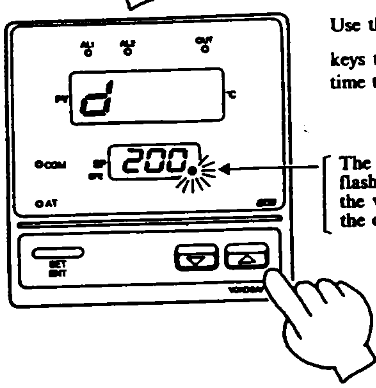
Note: The derivative time setting display is not shown when on/off control is in effect.

①



From the operating parameter setting panel, press the SET/ENT key several times to come to the display in the figure at left. (Verify that [d] is displayed.)

②



Use the △ and ▽ keys to set the derivative time to the required value.

The decimal point begins flashing. If you return to the value in effect before the change, it disappears.

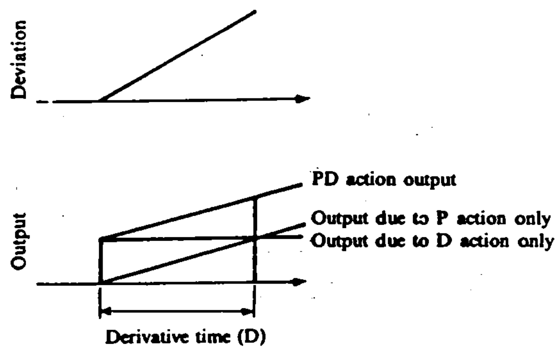
③ Press the SET/ENT key once. This completes the setting. (Note)

The decimal point disappears.

Note: See "Note 3" of the "Notes on Parameter Setting" (p. 20).

○ What is Derivative Time (D)?

If the controlled object has a large time constant or dead time, with P or PI action alone there will be cases where the response will be slow, overshoot will occur, and the control system will be unstable. In order to achieve faster response and more stable operation in these cases one uses derivative action ("D" action) to apply an output component proportional to the input (deviation) rate-of-change. D action must always be used with P action or PI action as PD or PID action. What we call the derivative time (D) will be that time required with PD action, if a ramp input (constant rate-of-change input) is applied, for the output due to P action alone to become equal to that due to D action alone. The longer the derivative time, the stronger the derivative action.



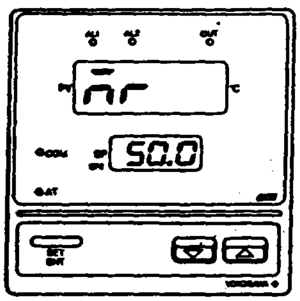
The procedure for setting the proportional band (P2) to the derivative time (D2) for the second setpoint is the same as for the proportional band (P) to the derivative time (D) for the main setpoint (Sections 7.5 to 7.7), and is therefore omitted here.

7. 8 Other Operating Parameter Setting Procedures

- The other operating parameters are as follows:
  - Manual reset value (MR)
  - Cycle time (CT)
  - On/Off control hysteresis (HYS)
  - Main set point (SP)
  - Sub set point (SP2)
  - Measurement input bias (BS)
- These parameters should be entered after displaying the setting display panel for the individual parameter as shown below. (Use the SET/ENT key.)

  The setting procedure is the same as steps ② and ③ in Section. 7. 1, "Alarm Value Setting Procedure" (p.22 and 23).

7. 8. 1 Manual Reset Value (MR)



Enter this parameter from the setting display panel at left.

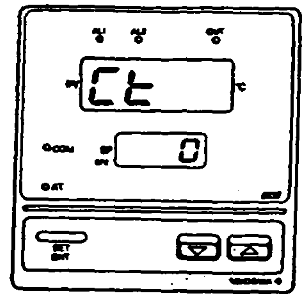
Verify that [nr] (MR) is displayed.

The manual reset value setting panel is not displayed when on/off control is in effect.

○ What is Manual Reset Value (MR)?

With P action or PD action alone the deviation can never be made to be zero at all times. The residual deviation is called offset. Manual reset is the output when PV=SP in steady state. (Integral action is a function that performs this reset action automatically, it is referred to as automatic reset.)

7. 8. 2 Cycle Time (CT)



Enter this parameter from the setting display panel at left.

Verify that [Ct] (CT) is displayed.

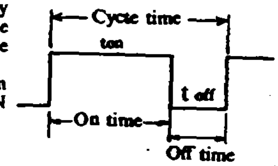
(The cycle time setting panel is displayed only for time-proportioning PID output.)

○ What is cycle Time (CT)?

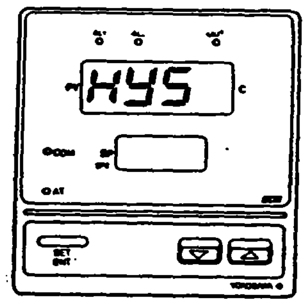
When time-proportioning PID output (relay output or voltage pulse output) is used, the PID computation result is output as the pulse width of an on/off signal.

The time proportion of this output in percent corresponds to the ratio of the ON time to the cycle time.

On time + Off time = Cycle time



7. 8. 3 On/Off Control Hysteresis (HYS)



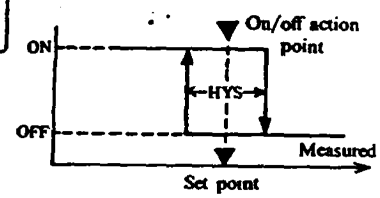
Enter this parameter from the setting display panel at left.

Verify that [HYS] (HYS) is displayed.

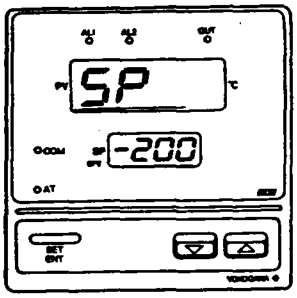
(The on/off control hysteresis setting panel is displayed only when on/off control is in effect.)

○ What is On/Off Control Hysteresis (HYS)?

The on/off control hysteresis is a "gap" set as necessary around the on/off action point in order to prevent control output chattering.

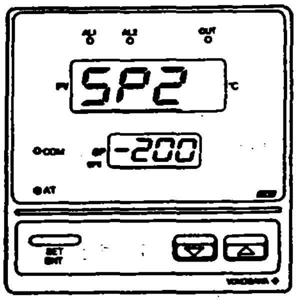


7. 8. 4 Main Set Point (SP)



Enter this parameter from the setting display panel at left.
Verify that SP (SP) is displayed.

7. 8. 5 Second Set Point (SP2)

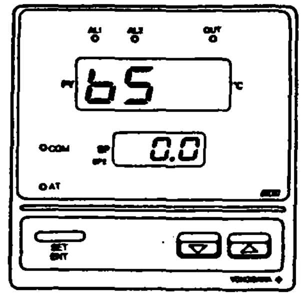


Enter this parameter from the setting panel at left. Verify that SP2 (SP2) is displayed.

Note 1: The SP and SP2 values set here can also be changed by the operating display panel operations described in Section 8, "Set Point Setting" (p.44).

Note 2: The UT15 and UT14 operate with each set of PID constants regardless of whether SP or SP2 is used as the setpoint.

7. 8. 6 Measurement Input Bias (BS)



Enter this parameter from the setting display panel at left.
Varify that bS (BS) is displayed.

o What is Measurement Input Bias (BS)?

This function can be used when such error or difference as follows is observed; extension lead wire error, RJC error caused by the wire size or the environmental factors such as a wind, and the difference of temperature between the furnace to be controlled and the sensor's actual location. That difference or error can be entered into the measurement input bias as a compensating value. This allows control and display to be performed using, as the measured input value, the actual measured-input value plus the measured-input bias.

PV actual + Bias = PV utilized

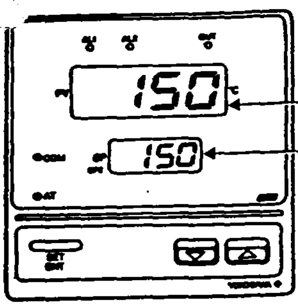
For example, in the following case we would set BS = 7°C

- Furnace internal temperature (T1): 1000°C
- Measured temperature (T2) at sensor location: 993°C
- Range (full scale): −200 to 1200°C

(As this indicates, the entry can be input in the units in use at that time.)

8. SET POINT SETTING

①

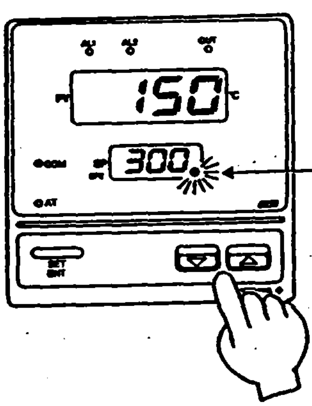


Verify that the instrument is in the orpating display mode (measured-value display panel).

Measured-value display

Set point display

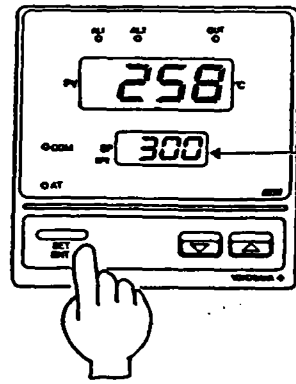
②



Using the △ and ▽ keys, set the set point to the required value.

The decimal point in the setting value display area will begin flashing. If you return to the value in effect before changes were made, the decimal point will either light continuously or disappear (when integral number).

③



Press the SET ENT key.

Entry of the new set point is completed.

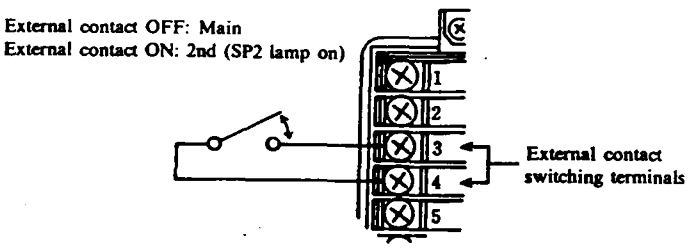
The decimal point either lights continuously or disappears. (when integral number)

Notes:

1) If at step ① the SP2 lamp is on, the set point setting will be for the second set point.
2) In step ③ be careful not to press the SET ENT key continuously for three seconds or more.(See Section 6.2, "Principles of Key Operations" (p. 18)).
3) If at step ③ the SET ENT key is not pressed and no key operations are performed for one minute or more, the instrument automatically returns to its state at step ① (and the instrument operates as it would if step ② had never been performed). Thus the set point is not changed.

9. OPERATION

- When you have completed the preparations described in Section 2, "Before Beginning Operations" (p.4) you can begin actual operation.
- The UT15 or UT14 will begin operating as soon as power is supplied. The instrument should be set so that the operating display is shown during actual operation. (See p.17).
- To change the set point during operation, follow the instructions on p.44.
- To change operating parameters during operation, follow the instructions on p.20 through 43.
- Switching between the two set points "main" and "second" can be performed by opening and closing an external contact. (This switching cannot be done using the keys.)
  However, if you switch between the two setpoints, set the range of parameter DIS to "0". (DIS is set to 0 upon shipment.)



- If an "error display" should appear during operation, see p.51 for the action that should be taken.

□When Power Is Lost During Operation

i) Momentary power outages in which power is lost for less than 20 ms have no effect on UT15/UT14 operation (operation continues normally).

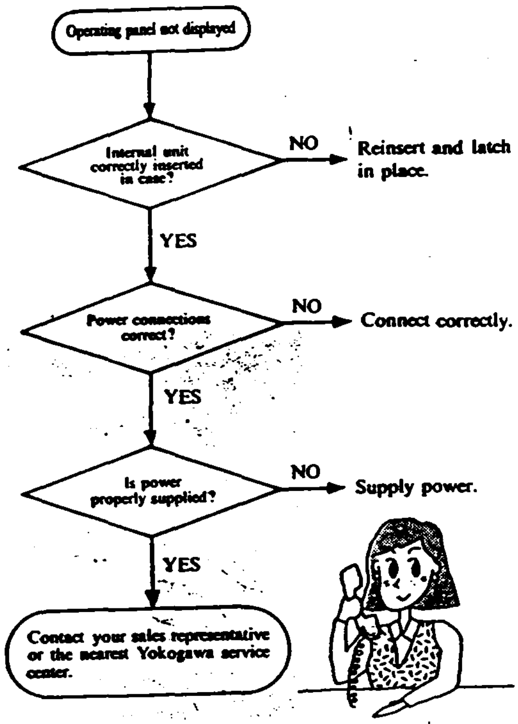
ii) • When power is restored (after a power outage longer than 20 ms), the operation in effect immediately before power was lost is continued.
  • The control output value will restart from 0% (for a 4 to 20 mA output) or OFF (for a relay or voltage pulse output).
  • If a power outage occurs while auto tuning is in progress, auto tuning is cancelled.
  • For about two seconds after power is restored, the input range code and output type code are displayed in the measured value display area.
  • Even when power is lost, values such as set points, alarm values, PID constants, etc. that have already been entered are maintained.

Note: However, if power is lost while a numeric value is being set using the keys, error code E400 may be displayed in some cases. (See Section 10. 3, "Error Display" (p.51)

10. MAINTENANCE

the operating display panel is not displayed on the UT15 or , when power is applied, take action according to the following flowchart. If you suspect a serious problem, contact your sales representative or the nearest Yokogawa service center.

Troubleshooting flowchart



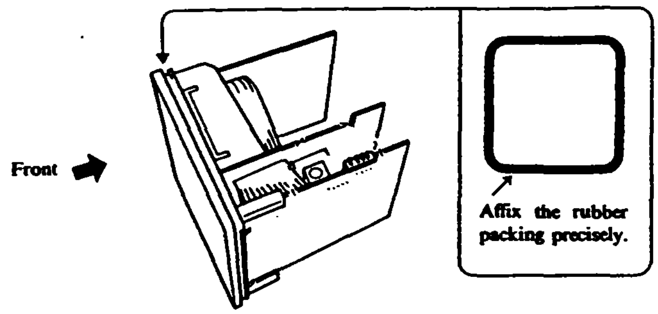
10. 1 Replacement of Rubber Gasket for Dustproofing/Anti O_3

Since the dustproof, anti O_3 rubber packings are consumables, avoid using perished rubber packings and replace them with new ones. The following table shows the part number, order quantity, and price of the rubber packings. When the UT15/UT14 is shipped from the factory, the dustproof rubber packing is mounted.

Type		Part number	Sales unit
UT15	Dustproof	B9877AJ	1 piece
	Anti O_3	B9877AL	1 piece
UT14	Dustproof	B9877FJ	1 piece
	Anti O_3	B9877FL	1 piece

⚠ CAUTION

Turn the power OFF when removing the internal unit.



10. 2 Control Output Relay Replacement

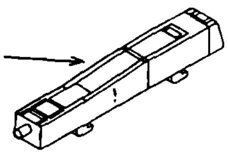
If the control output relay deteriorates it should be replaced.
The UT15 and UT14 use DSP1-DC12V relays (Matsushita Electric).
They may be ordered from your YOKOGAWA SALES REPRESENTATIVE or MATSUSHITA ELECTRIC OFFICES.

10. 3 Replacing the Bracket (Installation Hardware)

If the bracket is damaged or lost, purchase new brackets using the following ordering information:

Type	Part number	Sales unit
UT15/UT14	B9877BA	2 piece

Brackets
(installation hardware)
[one each on the upper and lower sections of the case]



10. 4 Error Display

If any of the following are displayed, an error has been detected. Respond to these errors as indicated in the individual "action" entries.

Error display	Description of error	Output status	Action
E000 (E000)	RAM error	0% max. or OFF (relay)	Request repair
E001 (E001)	ROM error		
E002 (E002)	System data error		
E003 (E003)	Output rotary switch setting error	0% max. or OFF (relay)	Set the output rotary switch to the number corresponding to the required code, either 0, 1, or 2.
E300 (E300)	A/D converter error	(Note) 0% max. or OFF (relay)	Request repair
E400 (E400)	Parameter entry error	(Note) 0% max. or OFF (relay)	Check whether any parameters are incorrect, and reenter
Undefined display	Program failure	0% max. or OFF (relay)	Request repair

Error display	Description of error	Output status	Action
Measured-value (PV) decimal point flashing	Calibration data error	Operation continues with whatever inaccuracy has arisen	Request repair.
Measured value (PV) flashing	Non-volatile memory error		
rJC (RJC) and measured value (PV) alternately displayed	Reference junction compensation error		
b.oUt (B. OUT)	Burnout (including RTD)	0% max. or OFF (relay)	Check thermocouple or RTD connections
oUr (OVR)	Over-scale	Controller treats measured input value as 105% of input range, and continues control output	Check whether measurement input range is appropriate and whether sensor is Properly connected.
-oUr (−OVR)	Under-scale	Controller treats measured input value as −5% of input range, and continues control output	

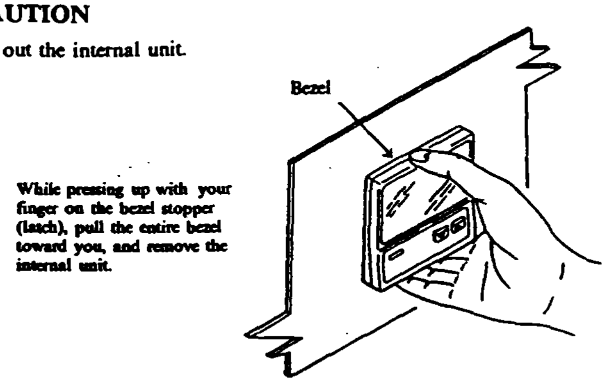
Appendix 1 Input/Output and Control Action Change Procedures

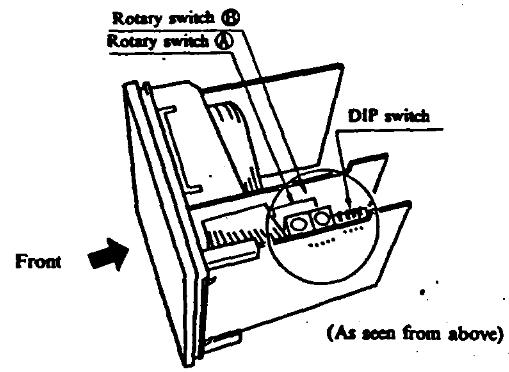
Follow the procedure below to remove and reinsert the internal unit.

① Remove power from the UT15/UT14 (turn power off).

⚠ CAUTION

② Pull out the internal unit.





(As seen from above)

③ When changes to the input, output, and control actions have been completed, return the internal unit to the case, and apply power.

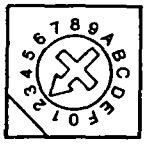
■ Measurement Input Range Code Change Procedure

The input range can be changed by setting the rotary switch Ⓐ arrow to the desired range code number using a screwdriver.
e range code No. is "0" when shipped from the factory.)

Table 1. Input Range Codes

			Input type range / instrument range (note 1)	Input range code (note 2)
Thermo-couple	JIS	K	−200~1200℃	0
		K	−199.9~200.0℃	1 Note
		S	0~1700℃	
		J	−199.9~800.0℃	2
		T	−199.9~400.0℃	3
		E	−199.9~800.0℃	4
		R	0~1700℃	5
		B	0~1800℃	6
		N	0~1300℃	7
	DIN	L	−199.9~800.0℃	8
		U	−199.9~400.0℃	9
RTD (note 3)	JPt100		−199.9~500.0℃	A
	Pt100		−199.9~500.0℃	B
mV, V, mA	0 to 10mV		Scaling is enabled in the following 4 ranges: −19999 to 9999, −199.9 to 999.9, −19.99 to 99.99, −1.999 to 9.999	C
	0 to 100mV			D
	0 to 5V			E
	1 to 5V (Note 4)			F

Note: Type of T.C. (K or S) can be selected when input range code is 1. (See P.54)



Set the rotary switch Ⓐ arrow to the desired range code.

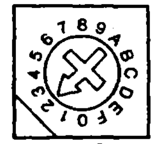
(Set for thermocouple type J in the example.)

Note 1: If instrument range "F" is required.
See Appendix 3 [Set Up Parameters] (Page 58).
Note 2: Number is the same as that of the rotary switch setting position.
Note 3: JIS '89 JPt 100, JIS '89 Pt100/DIN
Note 4: 4 to 20mA requires 250Ω 0.1% (accuracy) resistor between terminals ⑤ and ⑧

CAUTION: The parameters shown below are automatically initialized when input range code is changed.
Operating Parameters: A1, A2, HYS, SP, SP2, BS
Setup Parameters: HY1, HY2, PD, RH, RL, SP.UP, SP.DN

■ Control Output Type Code Change Procedures

The control output type code can be changed by using a screwdriver to set the rotary switch Ⓑ arrow to correspond with the desired control output type code No. (The control output type code No. is set at "0" when shipped from the factory.)



Set rotary switch Ⓑ to the desired control output type code No.
(In the example, the switch is set for continuous output PID.)

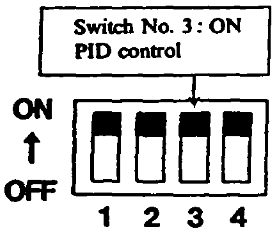
Control output type	Specifications	Control output type code
Relay output time-proportioning PID	Contact rating: 250 V AC, 3A (resistive load) Cycle time: 1 to 120 sec.	0*
Voltage pulse output Time proportional PID	ON voltage: Approx. 15 V DC OFF voltage: 0.1 V DC max. Cycle time: 1 to 120 sec.	1
Continuous output PID	Output current 4 to 20 mA (resistive load 600Ω max.) Accuracy ±0.3% (with respect to full scale) Output update interval: 500 ms	2

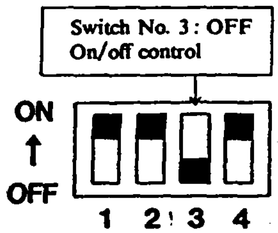
Note: There are only three control output type codes: 0, 1, 2 and If the rotary switch is not at position 0, 1, or 2, error "E003" is displayed.

*: The third alarm function cannot be used when the timeproportional PID relay output.

■ PID Control ↔ On/Off Control Change Procedure

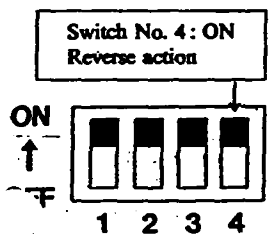
UT15 or UT14 can be used as either a PID or an on/off controller, according to whether DIP switch No. 3 is ON or OFF. (DIP switch No. 3 [illegible]N when shipped from the factory.)

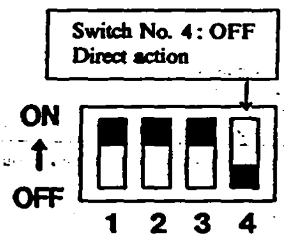




■ Direct Action ↔ Reverse Action Change Procedure

Either direct action or reverse action can be selected, according to whether DIP switch No. 4 is ON or OFF. (DIP switch No. 4 is ON when shipped from the factory.)



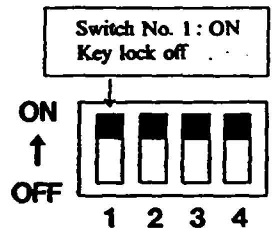


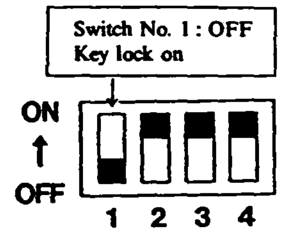
Appendix 2 Key Lock Setting Procedure

There are two ways for setting key lock.

■ Keylock by Dip switch

Setting DIP switch No. 1 to OFF turns on the key lock.
(The UT15/UT14 is shipped from the factory with the key lock disabled.)





■ Keylock by external contact

Set the Setup parameter DIS (p.68) to 1 (Key lock on).
Key lock is on when external contact (③–④) is closed, and off when external contact is open.
(See Terminal wiring diagram p.10).

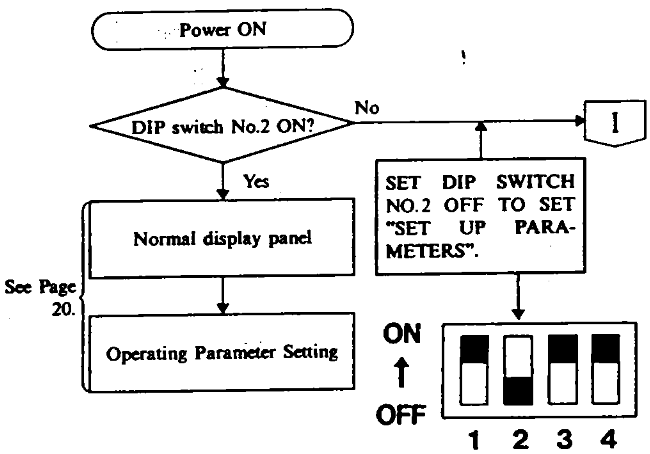
Appendix 3 Set Up Parameters

In addition to the operating parameters, the UT15/UT14 has various other parameters (these are referred to by the generic name "Set up parameters"). This appendix shows the way to set "Set up parameters".

Note

Be careful, as the operation of the instrument may not conform exactly to the descriptions in this manual once these setting have been changed. (ex. °C→°F etc)

"Set up Parameter" Setting Flowchart



The parameters which are shown with Ⓔ mark in the next page are those which are added upon the enhancement of the function.

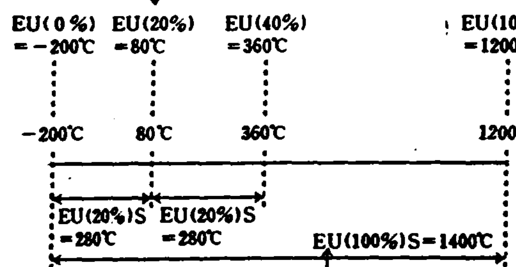
Mark	Parameter	Description
	(AL1)	Alarm 1 type
	(AL2)	Alarm 2 type
Ⓔ	(AL3)	Alarm 3 type
	(HY1)	Alarm 1 hysterisis
	(HY2)	Alarm 2 hysterisis
Ⓔ	(HY3)	Alarm 3 hysterisis
	(STC)	T.C. type (K or S) selection
	(UNIT)	Temp. display unit (for T/C, RTD input)
	(PD)	Decimal point position
	(RH)	Measurement range maximum value
	(RL)	Measurement range minimum value
	(OH)	Output high limit
	(OL)	Output lower limit
	(EOUT)	Error output code
	(AR)	Anti reset wind up
	(SP.UP)	SP up-ramp slope
	(SP.DN)	SP down-ramp slope
	(SP.R)	Slop setting unit
	(FL)	Input filter
	(ADDR)	Address (only with /RS422 option)
	(BPS)	Communication rate (only with /RS422 option)
	(PARI)	Parity (only with /RS422 option)
	(STOP)	Stop bit (only with /RS422 option)
	(D.LEN)	Data length (only with /RS422 option)
Ⓔ	(AMS)	Auto/manual select function setting
Ⓔ	(RJC)	Reference junction temperature compensation
Ⓔ	(DIS)	DI Selection

CAUTION: The parameters shown below are automatically initialized when the value of STC and/or UNIT is changed.
Operating Parameters: A1, A2, HYS, SP, SP2, BS
Setup Parameters: HY1, HY2, PD, RH, RL, SP.UP, SP.DN

- The UT15 and UT14 use certain symbols unique to these instruments to represent the parameter units. These symbols are described below.

The following illustrates EU( ) and EU( )S (for a range of −200 to 1200 ℃)

EU( ): Absolute value in engineering units corresponding to the range



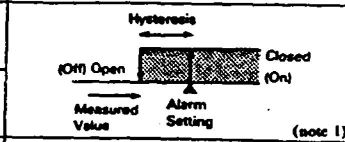
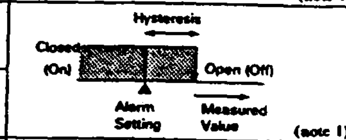
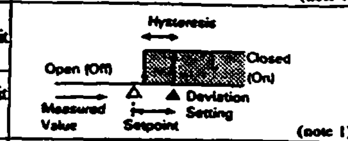
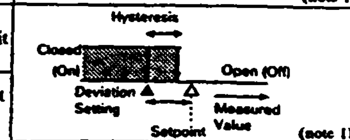
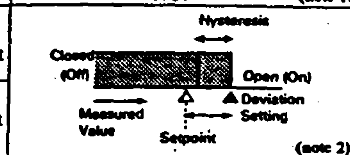
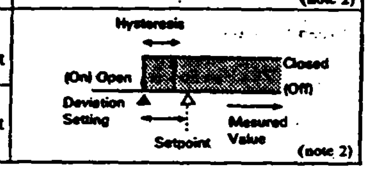
EU( )S: Span value in engineering units corresponding to the span

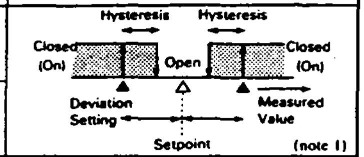
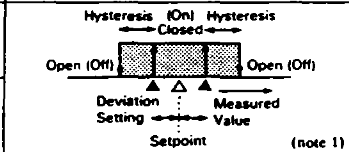
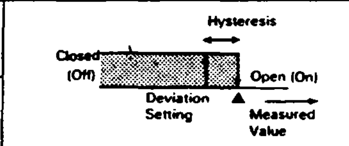
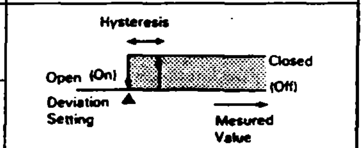
● SET UP PARAMETERS (AL1 and AL2)

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
AL1 (AL1)	Alarm 1 type	OFF or 1~20	1	
AL2 (AL2)	Alarm 2 type	OFF or 1~20	2	
AL3 (AL3)	Alarm 3 type	OFF or 1~21	1	

└See Table 1 for the relationship between alarm types and parameter codes.

Table 1

Code	Alarm type	Action
OFF	No alarm	No action
1	Measured value high limit alarm	
11	Measured value high limit alarm with standby	
2	Measured value low limit alarm	
12	Measured value low limit alarm with standby	
3	Deviation upper limit	
13	Deviation upper limit with standby	
4	Deviation lower limit	
14	Deviation lower limit with standby	
5	De-energized on deviation upper limit	
15	De-energized on deviation upper limit with standby	
6	De-energized on deviation lower limit	
16	De-energized on deviation lower limit with standby	

Code	Alarm type	Action
7	Deviation upper-lower limit	
17	Deviation upper-lower limit with standby	
8	Within upper-lower deviation limits	
18	Within upper-lower deviation limits with standby	
9	De-energized on measured value high limit alarm	
19	De-energized on measured value high limit alarm with standby	
10	De-energized on mesured value low limit alarm	
20	De-energized on mesured value low limit alarm with standby	
21	FAIL OUTPUT	The contact will be opened when the instrument FAIL'S.

(Note 1) Contact closes when the alarm "ON".
(Note 2) Contact opens when the alarm "ON".

Note

When the standly operation is in effect, and any of the following conditions applies, no alarm is output even if a normal alarm condition is present, until the input (PV) has first entered into the normal condition.

- At power ON.
- Setpoint changed.
- Setpoint switched from "main" to "sub".

● SET UP PARAMETERS (HY1 and HY2)

See table 1 concerning the concept of hysterisis.

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
HY1 (HY1)	Alarm 1 hysterisis	EU(0.0%)S ~EU(100.0%)S	EU(0.5%)S	
HY2 (HY2)	Alarm 2 hysterisis	EU(0.0%)S ~EU(100.0%)S	EU(0.5%)S	
HY3 (HY3)	Alarm 3 hysterisis	EU(0.0%)S ~EU(100.0%)S	EU(0.5%)S	

● SET UP PARAMETERS (STC)

Displays when input range code is "1".

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
StC (STC)	T.C. type (K or S) selection	0 or 1 (type K) (type S)	0	

CAUTIOU: Some parameters are automatically initialized when the value of STC is changed. (See Page 55)

● SET UP PARAMETERS (UNIT)

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
Unit (UNIT)	Temp. Display unit	°C or °F	°C	

The instrument range for thermocouple and RTD can be specified as °C or °F, according to the following table.

CAUTION: Some parameters are automatically initialized when the value of UNIT is changed. (See Page 55)

			℃	°F
Thermo couple	JIS	K	−200~1200℃	−300~2300°F
		K	−199.9~200.0℃	−300~400°F
		S	0~1700℃	0~3100°F
		J	−199.9~800.0℃	−300~1500°F
		T	−199.9~400.0℃	−300~750°F
		E	−199.9~800.0℃	−300~1500°F
		R	0~1700℃	0~3100°F
		B	0~1800℃	0~3300°F
		N	0~1300℃	32~2400°F
	DIN	L	−199.9~800.0℃	−300~1500°F
		U	−199.9~400.0℃	−300~750°F
RTD	JPt100		−199.9~500.0℃	−199.9~999.9°F
	Pt100		−199.9~500.0℃	−199.9~999.9°F

● SET UP PARAMETERS (PD)

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
Pd (PD)	Decimal point position	0, 1, 2 or 3	1	

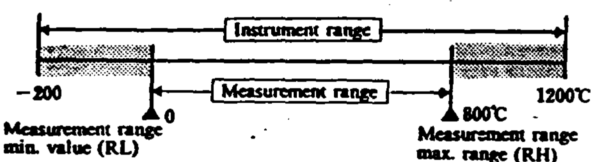
0: No digit below decimal point
1: 1 digit below decimal point
2: 2 digit below decimal point
3: 3 digit below decimal point (can be selected for DC voltage input)

● SET UP PARAMETERS (RH, RL)

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
rH (RH)	Measurement range max. value	EU(0.0%) ~EU(100.0%)	EU(100.0%)	
rL (RL)	Measurement range min. value	EU(0.0%) ~EU(100.0%)	EU(0.0%)	

☐ Measurement Range Change (Using RH, RL)

The measurement range can be changed by entering a new measurement range max. value or min. value.



☐ Scaling (Using PD, RH and RL)

In the case of DC voltage input, a conversion to actual scale and decimal point position can be specified. (In the following example, a 1 to 5 V DC input is scaled to 0.0 to 800.0.)

(Example)

Input voltage	1	2	3	4	5 VDC
Measurement range after scaling	0.0	200.0	400.0	600.0	800.0
Value before scaling	0.0	25.0	50.0	75.0	100.0

● SET UP PARAMETERS (OH, OL)

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
oH (OH)	Output high limit	−4.9 to 105.0% of output	100.0% of output	
oL (OL)	Output lower limit	−5.0 to 104.9% of output	0.0% of output	

Note: Can not be set for relay or voltage pulse output ON-OFF control.

Specify when restrictions are to be placed on the output value. The operating range of the restricted output is limited to the range between the output lower limit (OL) and the high limit (OH).

● SET UP PARAMETERS (EOUT)

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
EoUt (EOUT)	Error output code	0 or 1	0	

0: Output on error → OFF or 0%
1: Output on error → ON or 100%

Errors are followings
- T/C, RTD burnout
- A/D converter error
- Setting data error

● SET UP PARAMETERS (AR)

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
Ar (AR)	Anti reset wind up	0.0~999.9%	0.0	

0: When the output value reaches the high or low limit, the temperature controller automatically determines the point where the PID computation is started.
0.1 to 999.9: When the output value reaches the high or low limit and when deviation reaches AR(%) of the proportional band, the PID computation is started. (This function was added in July, 1994.)

● SET UP PARAMETERS (SP. UP, SP. DN and SP. R)

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
(SP. UP)	SP up-ramp slope	OFF, or EU(0%)/min. or hr.~ EU(100%)/min. or hr.	OFF	
(SP. DN)	SP down-ramp slope	OFF, or EU(0%)/min. or hr.~ EU(100%)/min. or hr.	OFF	
(SP. R)	Slop setting unit	0 : °C/hr. or 1 : °C/min.	0	

□When you do not want the setpoint (SP) to change suddenly, or when you want it to change with a constant slope, (SP. UP) and (SP. DN) set the slope values to increase or decrease.
This feature functions in the following three situations:

- When the setpoint is changed.
- When the setpoint is switched between (main) and (sub.:2nd).
- When power is turned ON (or when it is restored after a power outage).

When power is turned ON, or is restored, the value goes from the current measured-value to the setpoint, and the effective setpoint (SP) changes according to the slope that has been specified.

□The slope setting units for both up-ramp (SP. UP) and down-ramp (SP. DN) can be specified as either "/hr." or as "/min.". When shipped from the factory, "/hr." is selected.

Note: The amount of increase or decrease in the setpoint for each output update period is truncated to a certain resolution. Therefore, if the range is broad and a very gradual slope has been specified, a slight disparity may arise in the setpoint (SP) after a long time has elapsed.

● SET UP PARAMETERS (FL)

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
(FL)	Input filter	OFF (no filter), or 1 to 120 seconds	OFF	

Use when there is a high level of noise in the measurement input, and the display value fluctuates.
The filter is a first-order lag type low-pass filter, the larger the time constant, the greater the noise rejection capability.

(a) Input (b) Example with 2-second filter inserted (c) Example with 10-second filter inserted

● SET UP PARAMETERS (ADDR to D. LEN)

Displayed only if /RS422 is specified as an option suffix code. See IM 5B4A7-50E concerning communications.

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
(ADDR)	Communication address	1 to 16	1	
(BPS)	Communication rate	0 to 6	6 (9600 BPS)	
(PARI)	Parity bit	0, 1 or 2	0 (no parity)	
(STOP)	Stop bit	1 or 2	1, (1 bit)	
(D.LEN)	Data length	7 or 8	8 (8 bit)	

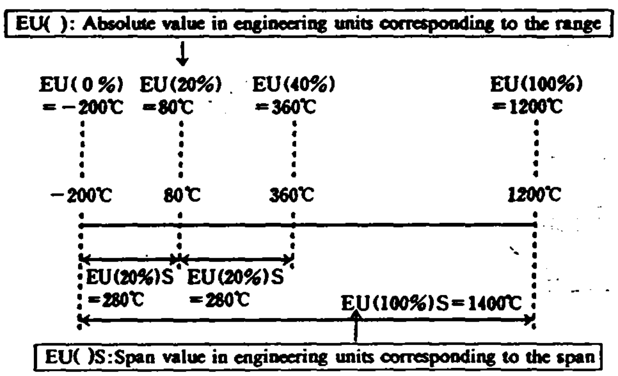
● **SET UP PARAMETERS (AMS to DIS)**

Symbol	Description	Setting range	Value when shipped from factory	Customer's set value
(AMS)	Auto/Manual Select function setting	OFF: Not display parameters ON : Display parameters	OFF	
(RJC)	Reference junction temperature compensation	OFF or ON	ON	
(DIS)	DI Selection	0 : Setpoint 2 selection 1 : Key lock/ unlock	0	

Appendix 4 Parameters (Including Set Points) Summary

- Refer to the tables at right when performing individual settings according to Section 7, "Operating Parameter Setting", and Section 8, "Set point Setting".
- The UT15 and UT14 use certain symbols unique to these instruments to represent the parameter units. These symbols are described below.

The following illustrates EU( ) and EU( )S (for a range of −200 to 1200 °C)



Revision Record

January 1995 IM 5B4A7-03E New Edition
October 1995 IM 5B4A7-03E 2nd revision

UT15 and UT14 have a better input accuracy and additional functions from the manufacturing of the begining of March 1995. The manufacturer add the letter "E" to the model name on the front panel, in order to distinguish from the former product.

Because there are some differences in suffix codes and parameters between old and new products, please take care when you replace the product.

HmS WAS OFF

Parameters (set points and operating parameters) summary

	Symbol	Description	Setting range	Value when shipped from factory	Customer's setting
Set point value	SP (SP)	Set point value *	EU (0%) ~EU (100%)	EU (0%)	

└Entered from operating display

	Symbol	Description	Setting range	Value when shipped from factory	Customer's setting
Parameters	A1 (A1)	Alarm 1 (measurement high limit alarm setting)	Note EU (0%) ~EU (100%)	EU(100%)	
	A2 (A2)	Alarm 2 (measurement low limit alarm setting)	Note EU (0%) ~EU (100%)	EU (0%)	
Ⓔ	A3 (A3)	Alarm 3 (measurement high limit alarm setting)	Note EU (0%) ~EU (100%)	EU(100%)	
Ⓔ	A/M (A/M)	Auto/Manual Selection	MAN or Auto	Auto	
	SC (SC)	"Super" function ON/OFF	ON or OFF	OFF	
	At (AT)	Auto tuning ON/OFF	ON or OFF	OFF	
	P (P)	Proportional band	0.1% ~300.0%	5.0%	
	I (I)	Integral time	OFF, or 1 sec. to 3600 sec.	240 sec.	
	d (D)	Derivative time	OFF, or 1 sec. to 3600 sec.	60 sec.	

Note: Setting range of "deviation alarm (See P.56, 57) is −100 to 100% of instrument range span.

	Symbol	Description	Setting range	Value when shipped from factory	Customer's setting
Ⓔ	P2 (P2)	Proportional band	0.1% ~300.0%	5.0%	
Ⓔ	I2 (I2)	Integral time	OFF or 1 sec. to 3600 sec.	240 sec.	
Ⓔ	d2 (D3)	Derivative time	OFF or 1 sec. to 3600 sec.	60 sec.	
Parameters	Mr (MR)	Manual reset value	−5.0% ~105.0%	50.0%	
	Ct (CT)	Cycle time	1 sec. to 120 sec.	10 sec.	

└Can be set only for time-proportioning PID output.

	Symbol	Description	Setting range	Value when shipped from factory	Customer's setting
	HYS (HYS)	On/off control hysteresis	EU(0.0%)S ~EU(100.0%)S	EU(0.5%)S	

└Can be set only for on/off control.

	Symbol	Description	Setting range	Value when shipped from factory	Customer's setting
	SP (SP)	Main set point *	EU (0%) ~EU (100%)	EU (0%)	
	SP2 (SP2)	Second set point *	EU (0%) ~EU (100%)	EU (0%)	
	bS (BS)	Measurement input bias	EU(−100.0%)S ~EU(100.0%)S	EU(0.0%)S	

* The set point entered (changed) from the operating panel may be either the main (SP) or 2nd (SP2) set point, whichever is display is accompanied by a change in the value of SP or SP2 (whichever is in use at that time) in the operating.

Ⓔ The parameters which are added upon the enhancement of the function.

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Instruction Manual

UT15L
FM APPROVED
LIMIT CONTROLLER

CONTENTS

YOKOGAWA ◆
YOKOGAWA Electric Corp.

IM 5B4A7-11E
1996. Mar. 3rd Edition

1. WHEN YOU RECEIVE THIS INSTRUMENT

Thank you for purchasing the UT15L. FM approved Limit 'roller. Please read this "Instruction Manual" carefully, and use ıstrument correctly.

Notes on Handling the UT15L

Cleaning of the front panel, key switches, etc., should be limited to wiping lightly with a dry cloth.
Do not use any solvents such as alcohol, benzine, etc.

1.1 Checking Accessory Items

Check that all of the following items are present.

- UT15L main unit .... 1 unit
- Bracket (installation hard ware) .... 2 pcs.
- Unit seals (labels) .... 1 sheet
- Instruction Manual (main text) .... 1 copy
- Instruction Manual (communication volume) .. 1 copy*

* Included only when option / RS422 is specified.

1.2 Verifying Product Specifications

Verify that the product delivered agrees with the model code ordered.

Model	Suffix code		Description
UT15L	·····		Limit Controller
Style code		*A	Style A
Optional features		/RET	Retransmission (4 to 20mA DC)
		/RS422	RS-422A Communication interface

1.3 Verifying Measurement Input Type and Control Output Type

- Unless otherwise specified, the UT15L is shipped from the factory set up as follows:
- Measurement input range code : 0 (thermocouple type K, −200 to 1200°C)

2. INSTALLATION

2.1 Installation Location

Install the instrument in a location that meets the following criteria.

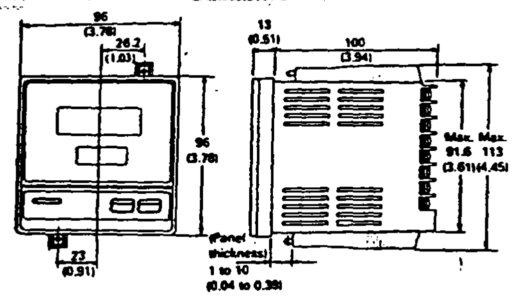
(1) Little or no mechanical vibration.
(2) No corrosive gases.
(3) Minimal temperature fluctuation, and near normal temperature (32°F to 122°F).
(4) Not directly subject to radiant heat.
(5) Not subject to strong electromagnetic fields.
(6) No direct exposure to water.

2.2 Installation Procedure

(1) Insert the instrument from the front of the panel.
(2) To fasten the instrument to the panel, use the accessory installation brackets provided.
<u>Take care not to overtighten the bracket screws when mounting.</u>

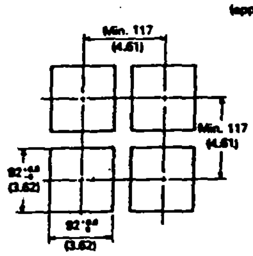
2.3 Outside Dimensions and Panel Cutout Dimensions

Dimensions



Panel Cutout and Spacing

Unit: mm (approx. inch)



3. WIRING

3.1 Wiring Procedure

When wiring, see Section 3.3, "Terminal Wiring Diagrams", and observe the following precautions.

(1) In the case of thermocouple input, use the proper thermocouple extension wire type (compensating leads).

(2) For RTD input, use wiring having low conductor resistance, and no significant differences in resistance among the three conductors.

(3) For power supply wiring, use a cable or wiring with characteristics equal to or better than 600V vinyl insulated wire (JIS C3307). If necessary, insert a noise filter in the power supply circuit.

(4) The ground conductor should have at least a $2mm^2$ crosssectional area, with resistance to ground not exceeding 100Ω maximum.

(5) Plan the input circuit wiring so as to avoid noise pickup.

(a) The input circuit wiring should be kept as far away as possible from power and ground circuits.

(b) Use of shielded wire is effective against noise due to electrostatic induction. If necessary, connect the shield to the ground terminal of the UT15L. (Be careful that this does not result in a two-point ground.)

(c) Use of conductor pairs twisted with a short and constant spacing between twists is relatively effective against noise due to electromagnetic induction.

(6) For connecting the wiring to the terminals, we recommend use of crimp terminal lugs (3.5mm screw) with insulated sleeves.

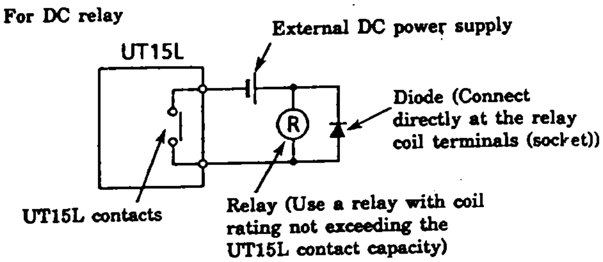
3.2 Cautions When Wiring

(1) There is no fuse or power supply switch in this instrument. If required, these must be provided separately.
For fusing, use time-lag fuses with a rated voltage of 250V, and a rated current of 1A.

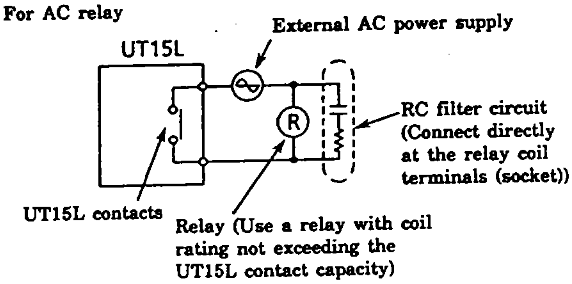
(2) If a load exceeds a relay output contact rating (control output : 250V, 3A AC resistive load : alarm output 250V AC, 1A resistive load), use an auxiliary relay to turn the load on and off.

(3) If using an inductive load such as an auxiliary relay on a relay contact output, connect a diode (for DC) or an RC filter (for AC) in parallel as a surge suppressor circuit to suppress sparking.

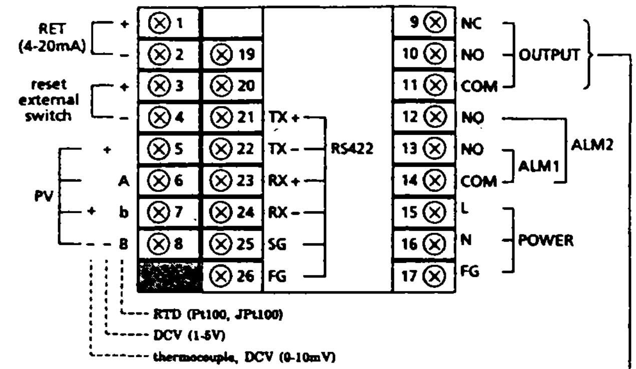
- For DC relay



- For AC relay



3.3 Terminal Wiring Diagram



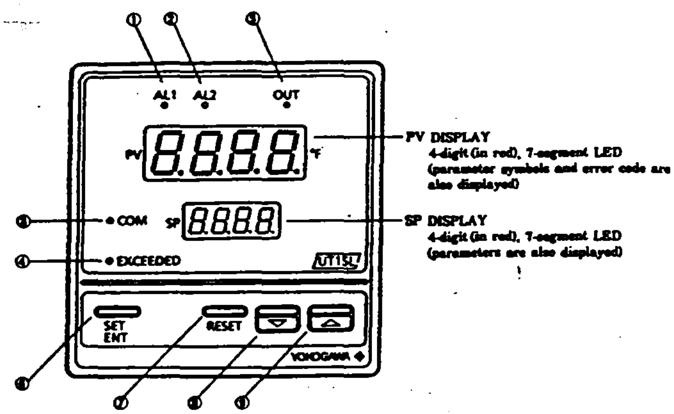
state of output terminals

	NC (9 - 11)	NO (10 - 11)
power off	close	open
limit on	close	open
limit off	open	close

⚠ WARNING

To avoid electric shock, never touch the power supply terminals, and the alarm output terminals when the power is on.
Carry out protective grounding to avoid electric shock.

FRONT PANEL DISPLAY AND USE



DISPLAY

① AL1 ··· Alarm indication lamp
: Lights up when the upper-limit alarm of a measured value occurs.

② AL2 ··· Alarm indication lamp
: Lights up when the lower-limit alarm of a measured value occurs.

③ COM ··· Status indication lamp
: Lights up during communication ; flashes when a communication error occurs.

④ EXCEED ··· Status indication lamp
: Lights up when the process variable exceeds the set point.

⑤ OUT ··· Output indication lamp
: Lights up when relay output is ON.

KEY

⑥ SET/ENT ··· Set-Entry key
: Used to set a value ; Changes when a parameter is selected.

⑦ RESET ··· Reset key
: Used to certify output ; Reset parameters.

⑧ ▽ ··· Down key
: Each digit automatically decreases.

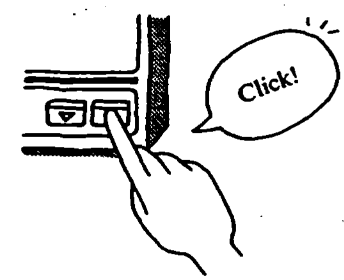
⑨ △ ··· Up key
: Each digit automatically increases.

note : SET/ENT 3sec : press SET/ENT (Set-Entry key) holding more than 3 second.

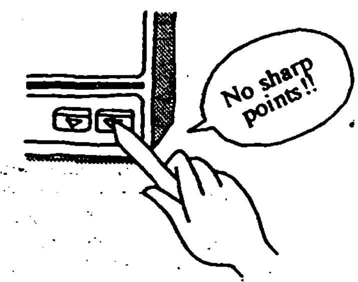
5. OPERATIONS

Notes on Key Operation

① The keys on this instrument have been designed with tactile feedback, and will click when pressed. Press firmly with your finger until you feel this click.



② Never use a sharp point to press the keys, as this can cause failure of the key.



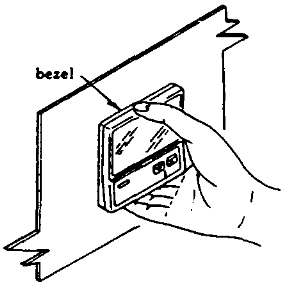
5.1 Input Change Procedures

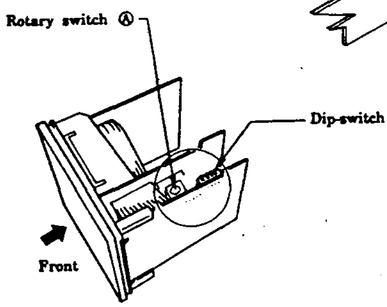
Follow the procedure below to remove and reinsert the internal unit.

(1) Remove power from the UT15L (turn off).

(2) Pull out the internal unit.

While pressing up with your finger on the bezel stopper (latch), pull the entire bezel toward you, and remove the internal unit.





By setting rotary switch Ⓐ inside the instrument and changing the terminal (for PV input) connections, you can switch the instrument to whichever of the input types and ranges in Table 1 that you desire.

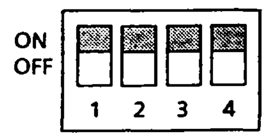
Table 1. Input Range Codes

	Input type / instrument range				Input range code
TC	JIS	K	-200 to 1200°C	-300 to 2300°F	0
		K	-199.9 to 200.0°C	-300 to 400°F	1
		J	-199.9 to 800.0°C	-300 to 1500°F	2
		T	-199.9 to 400.0°C	-300 to 750°F	3
		E	-199.9 to 800.0°C	-300 to 1500°F	4
		R	0 to 1700°C	0 to 3100°F	5
		B	0 to 1800°C	0 to 3300°F	6
		S	0 to 1700°C	0 to 3100°F	7
	DIN	L	-199.9 to 800.0°C	-300 to 1500°F	8
		U	-199.9 to 400.0°C	-300 to 750°F	9
RTD*1	JPt100		-199.9 to 500.0°F	-199.9 to 999.9°F	A
	Pt100				B
mV, V, mA	0 to 10mV		-1999 to 9999°F		C
	0 to 100mV		-199.9 to 999.9°F		D
	0 to 5V		-19.99 to 99.99°F		E
	1 to 5V		-1.999 to 9.999°F		F
	4 to 20mA				F*2

*1 JIS'89 JPt100, JIS'89 Pt100/DIN

*2 4 to 20mA requires 250Ω, 0.1% (accuracy) resistor between

5.2 Initialize by DIP switch



bit 1: Key lock
- ON : key unlocked
- OFF : key locked

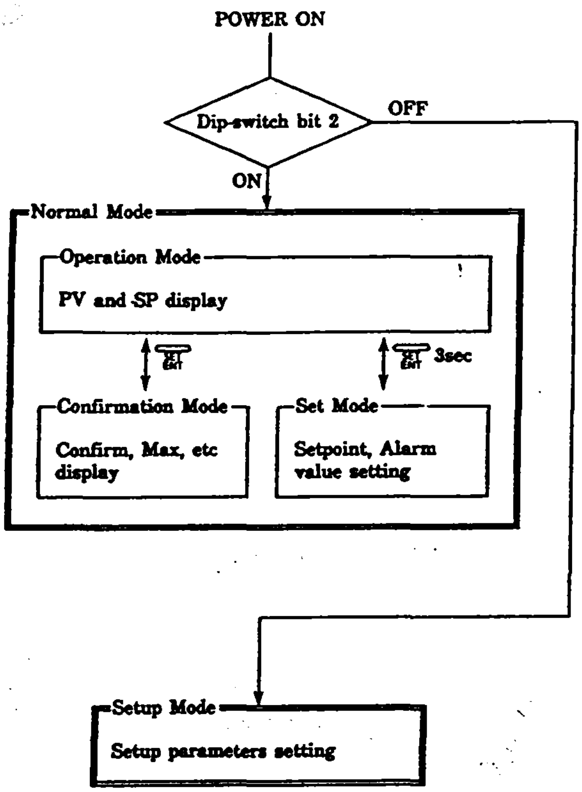
bit 2: mode (See Page 12 : 5. Key operation rules)
- ON : normal mode
- OFF : setup mode

bit 3: confirmation select (See Page 22 : 7.1 Confirmation)
- ON : RESET (RESET key)
- OFF : external contact switch

bit 4: limit type (See Page 18: 6. Limit Control action)
- ON : high limit type
- OFF : low limit type

5.3 Key Operation Rules

5.3.1 Basic Principles

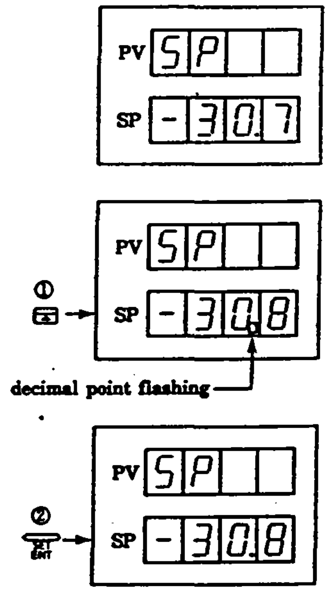


5.3.2 Data Change Process

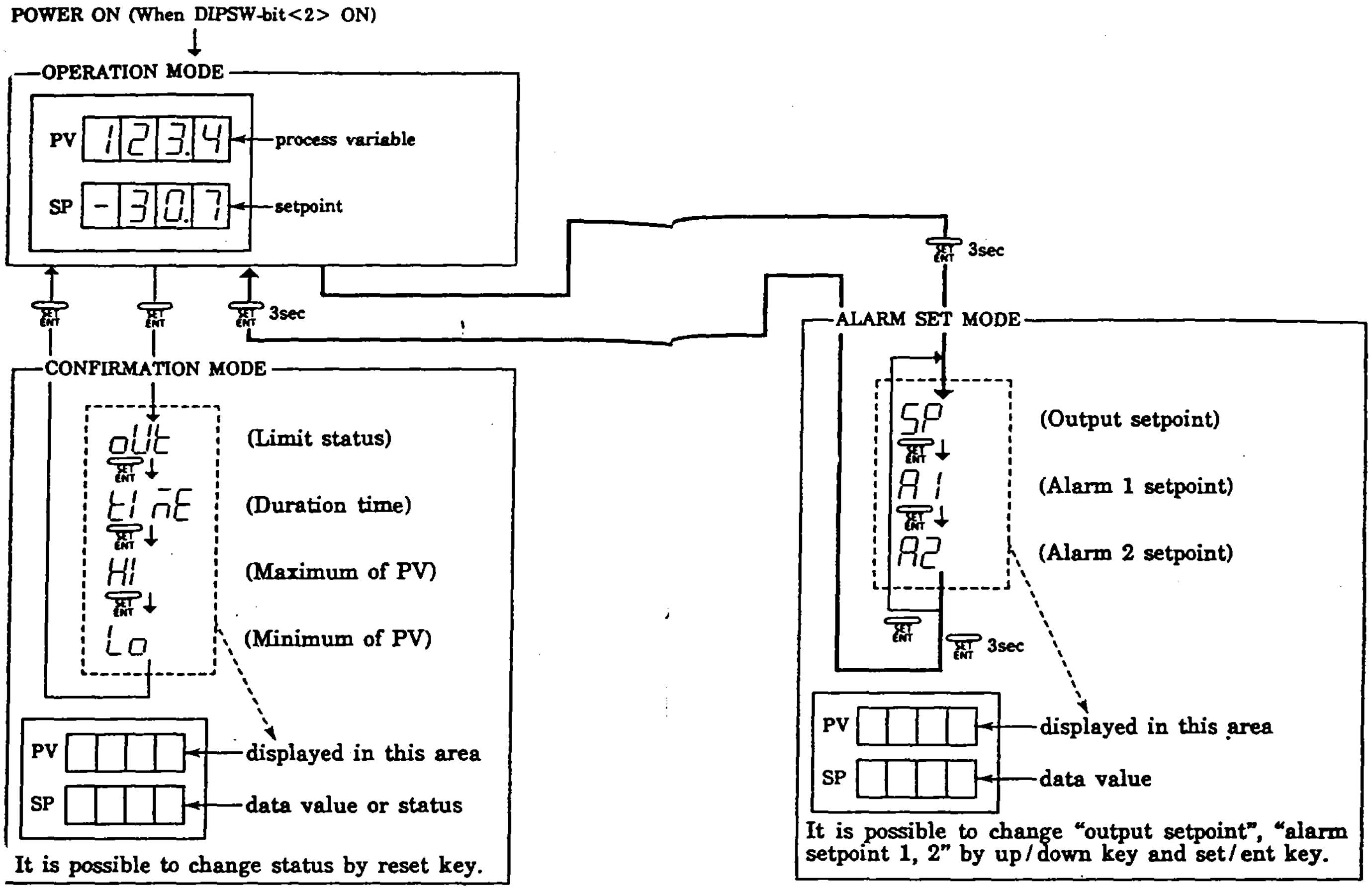
When (Up key) ((Down key)) is pressed, display data increments (decrements) and decimal point begins flashing (①).

And (Set-Entry key) is pressed then, display data is stored into memory (EEPROM) and decimal point stops flashing (②).

EX) SP change to −30.8 from −30.7

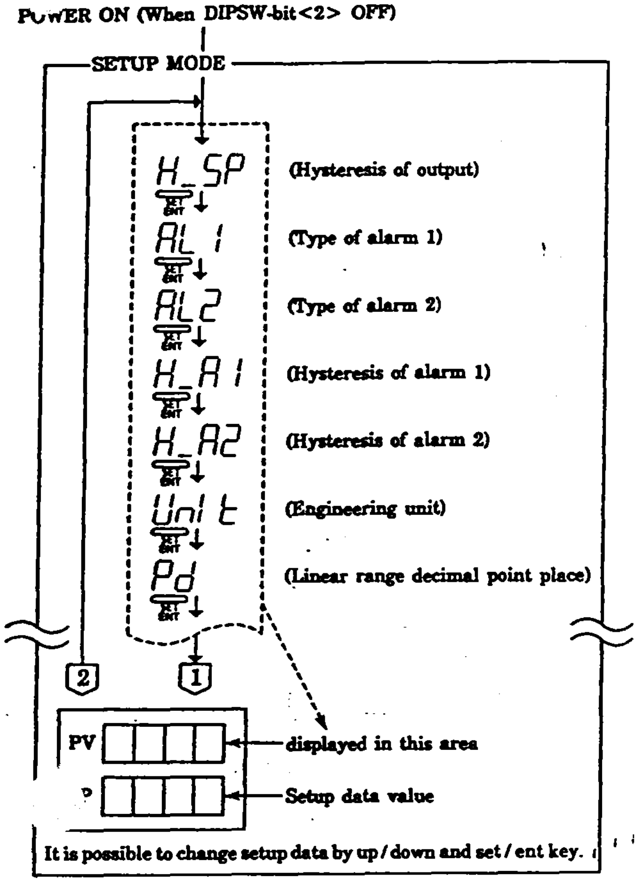


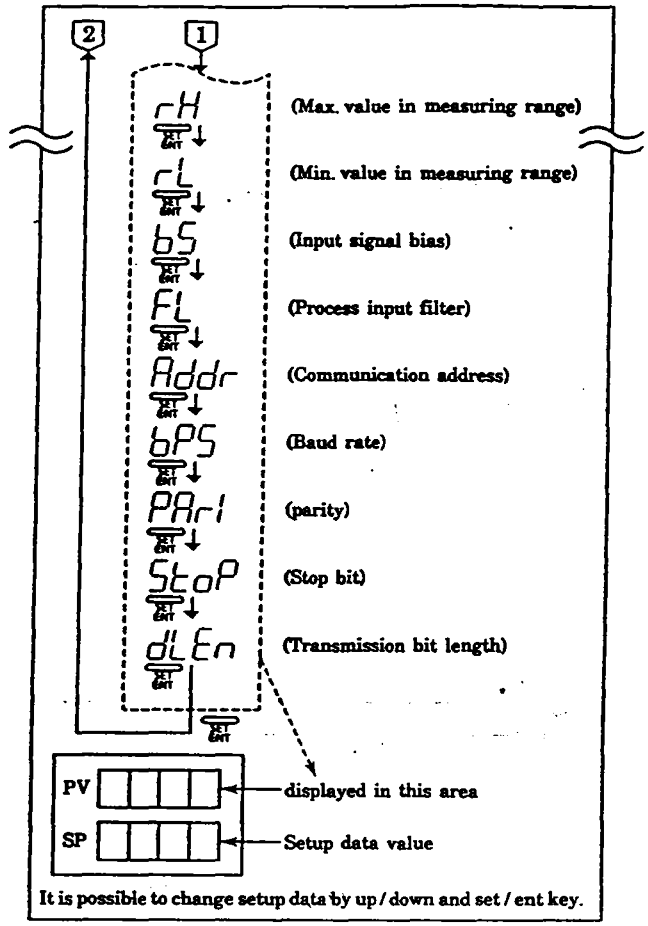
5.3.3 Normal Mode



Setup Mode

POWER ON (When DIPSW-bit<2> OFF)



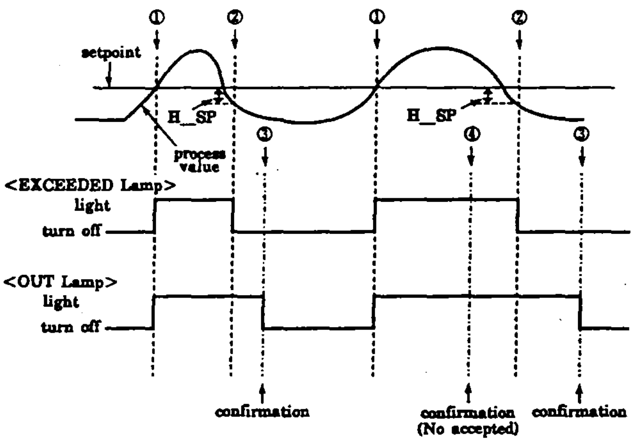


LIMIT CONTROL ACTION

6.1 Control Action

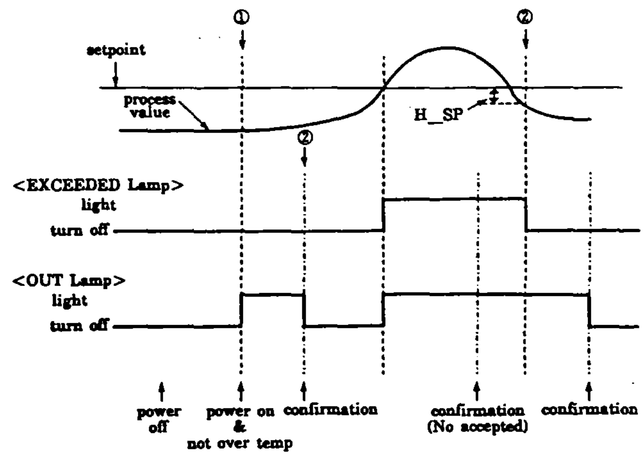
<Lock in action>

When process variable (PV) exceeds a setpoint (SP), "EXCEEDED" lamp and "OUT" lamp turn on (①).
"EXCEEDED" lamp turns off when PV goes into normal condition, however "OUT" lamp is stays on as it is (②).
"OUT" lamp turns off when a confirming operation is done by a operator (③) the way to confirm is pushing (Reset key).
The confirming operation is not accepted during PV exceeds SP (④).
State of output relay is di-energized, whenever "OUT" lamp is on. (It is same as power off, that is NC Terminal : CLOSE, NO Terminal : OPEN)



6.2 Power on Status

State of output relay is always di-energized at power on even if PV does not exceed SP (①), (NC Terminal : CLOSE, NO Terminal : OPEN) and after confirmation (manual reset) state of output relay is energized (②). (NC Terminal : OPEN, NO Terminal : CLOSE)



State of output relay is di-energized, whenever "OUT" lamp is on. (It is same as power off, that is NC Terminal : CLOSE, NO Terminal : OPEN)

7. CONFIRMATION MODE

T o n mo

From operation mode

SET/ENT

<LIMIT CONFIRMATION PANEL>

PV oUt

SP

Confirm a limit Control on this panel.

Push RESET (Reset key) to confirm "Limit".

SET/ENT

Display of "SP"	status
"on"	PV exceeded SP, but no confirmation is done yet.
"oFF"	PV does not exceed SP, and confirmation is already done, or PV has not exceeded SP since power was turned on.

<DURATION TIME DISPLAY PANEL>

PV tinE

SP

This panel displays the time that PV exceeded SP.

Push RESET (Reset key) to reset duration time.

Duration time=0.0~999.9 Min

The decimal point flashes when the controller is counting the duration time.

SET/ENT

Display of "SP"	status
"NNNN" (Duration time)	PV exceeds SP.
"00"	PV does not exceed SP, and confirmation is already done, or PV has not exceeded SP since power was turned on.

2 1 1'

2 1

<MAXIMUM VALUE DISPLAY PANEL>

PV HI

SP

This panel is displayed when high limit type is selected, and shows the maximum value of PV.

Push RESET (Reset key) to reset maximum value.

(This panel is not displayed when low limit type is selected.)

Maximum value of PV is indicated on "SP" display.

1'

<MINIMUM VALUE DISPLAY PANEL>

PV Lo

SP

This panel is displayed when low limit type is selected, and shows the minimum value of PV.

Push RESET (Reset key) to reset minimum value.

(This panel is not displayed when high limit type is selected.)

Minimum value of PV is indicated on "SP" display.

SET/ENT

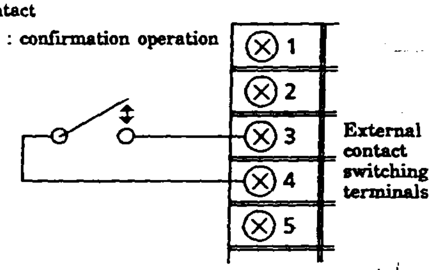
7.1 Confirmation (LIMIT CONFIRMATION PANEL)

- "on"(ON) lights (on LIMIT CONFIRMATION PANEL) when PV exceeds SP.
- "oFF"(OFF) is displayed when a limit confirmation operation (push RESET (Reset key)) is done during PV goes back to normal status.
- "on" is still lighted when PV exceeds SP even if operator makes confirmation operation.
- External contacts can be used for LIMIT confirmation. Closing external contacts is equal to push RESET (Reset key)) for confirmation.
  If you use external contacts for confirmation, you can confirm on other panel.
- Two types of confirmation operation can be selected by dip-switch bit-3 on PCB., which is RESET (Reset key)) on front panel operation or external contact operation.
  If dip-switch bit 3 is "ON" then key operation is enabled. (external contact operation is disabled)
  If dip-switch bit 3 is "OFF" then external contact operation is enabled. (key operation is disabled)

note : External contacts can not be used for duration time reset and maximum value or minimum value of PV reset.

■ External contact

OFF → ON : confirmation operation



7.2 Limit Duration (DURATION TIME DISPLAY PANEL)

- The time (during PV exceeds SP) is counted and displayed.
- Display time range : 0.0~999.9 minutes.
- Push RESET (Reset key) to reset time count (Reset key) to reset time count when "DURATION TIME DISPLAY PANEL" is displayed.
  And the time count are to be reset when power is turned on. When the time count are reset, "0.0" is displayed until PV exceeds SP again.
  If PV exceeds SP again during the old time count is retained in the memory, the old data should be reset and new time counting start from "0.0"

note : It is impossible to reset time count during PV exceeds SP by any operation.

7.3 Min/Max Memory

- The maximum value or minimum value of PV is displayed and stored in the memory.
- If RESET (Reset key)) is pushed during the controller displays maximum value or minimum value on the display, memory is reset and a PV (which is measured on that time) should be recognized as maximum value or minimum value.
  If PV exceeds SP again when the maximum value or minimum value is retained in the memory, the maximum value or minimum value should be reset and the first PV should be recognized as maximum value or minimum value.

note : When power is turned on, the memory should be reset and the first PV should be recognized as maximum value or minimum value.

Maximum value : When high limit type is selected.

Minimum value : When low limit type is selected.

8. PARAMETERS LIST

8.1 Normal Mode Parameters

MODE	CODE	SETTING ITEM	UNIT	INITIAL VALUE	SETTING RANGE, DESCRIPTION
OPERATION MODE	—	—	—	—	—
CONFIRMATION MODE	oUt	Limit status	—	ON	ON, OFF
	tinE	Duration time	Min	0.0	0.0 to 999.9
	Hi	Maximum of PV	EU	first PV	EU (0%) to EU (100%)
	Lo	Minimum of PV	EU	first PV	EU (0%) to EU (100%)
ALARM SET MODE	SP	Output setpoint	EU	EU (0%)	EU (0%) to EU (100%)
	A1	Alarm 1 setpoint	EU	EU (100%)	EU (0%) to EU (100%) EU (0%) S to EU (100%) S (EU ( ) S in deviation alarm)
	A2	Alarm 2 setpoint	EU	EU (0%)	

8.2 Setup Mode Parameters

MODE	CODE	SETTING ITEM	UNIT	INITIAL VALUE	SETTING RANGE, DESCRIPTION
SET UP MODE	H_SP	Hysteresis of output	EU	EU (0.5%) S	EU (0%) S to EU (100%) S
	AL1	Type of alarm 1	—	1	OFF, 1 to 8, 11 to 18 *1 (See Page 26 : Table 1)
	AL2	Type of alarm 2	—	2	
	H_A1	Hysteresis of alarm 1	EU	EU (0.5%) S	EU (0%) S to EU (100%) S
	H_A2	Hysteresis of alarm 2	EU	EU (0.5%) S	EU (0%) S to EU (100%) S
	UnIt	Engineering unit	—	℃	℃, ℉
	Pd	Linear range decimal point place	—	1	0:0 to 9999 1:0.0 to 999.9 2:0.00 to 99.99 3:0.000 to 9.999
	rH	Max.value in measuring range		ACCORDING TO RANGE CODE	For TC or RTD input RL<RH≤ (Range Max. value) For linear input RL<RH≤9999
	rL	Min.value in measuring range		ACCORDING TO RANGE CODE	TC, RTD input (Range Min.value) ≤RL<RH For linear input −1999≤RL<RH
	bS	Input signal bias	EU	EU (0%) S	EU (−100%) S to EU (100%) S
	FL	Process input filter	S	OFF	OFF and 1 to 120
	Addr	Communication address	—	1	1 to 16
	bPS	Baud rate	—	6	0 : 150, 1 : 300, 2 : 600, 3 : 1200, 4 : 2400, 5 : 4800, 6 : 9600
	PAri	Parity	—	0	0 : None, 1 : Even, 2 : Odd
	StoP	Stop bit	—	1	1:1 bit, 2:2 bit
	dLEn	data bits	—	8	7:7 bit, 8:8 bit

9. ALARM

Alarm setpoint	2 point
Output Relay	1A 250VAC NO contacts
ˉ̈ED lamp	2 point (AL1, AL2, on front panel)
ırm type	OFF, or 1~8, 11~18 (See Table 1 for the relationship between alarm types and parameter codes)

Table 1 (1/2)

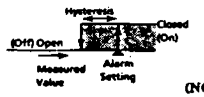
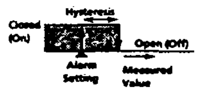
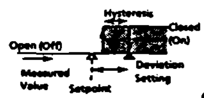
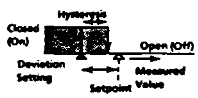
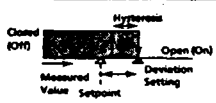
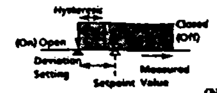
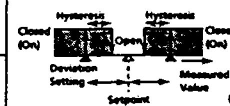
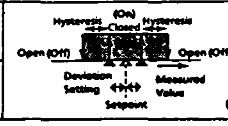
Code	Alarm type	Action
OFF	No alarm	No Action
1	Measured value high limit alarm	 (NOTE 1)
11	Measured value high limit alarm with standby	
2	Measured value low limit alarm	 (NOTE 1)
12	Measured value low limit alarm with standby	
3	Deviation upper limit	 (NOTE 1)
13	Deviation upper limit with standby	
4	Deviation lower limit	 (NOTE 1)
14	Deviation lower limit with standby	
5	De-energized on deviation upper limit	 (NOTE 2)
15	De-energized on deviation upper limit with standby	

Table 1 (2/2)

Code	Alarm type	Action
6	De-energized on deviation lower limit	 (NOTE 2)
16	De-energized on deviation lower limit with standby	
7	Deviation upper-lower limit	 (NOTE 1)
17	Deviation upper-lower limit with standby	
8	Within upper-lower deviation limits	 (NOTE 1)
18	Within upper-lower deviation limits with standby	

(note1) Contact closes when the alarm "ON".
(note2) Contact opens when the alarm "ON".

Note

When the standby operation is in effect, and any of the following conditions applies, no alarm is output even if a normal alarm condition is present, until the input (PV) has first entered into the normal condition.

- At power ON.
- Setpoint changed.
- Setpoint switched from "main" to "sub".

10. OPERATION

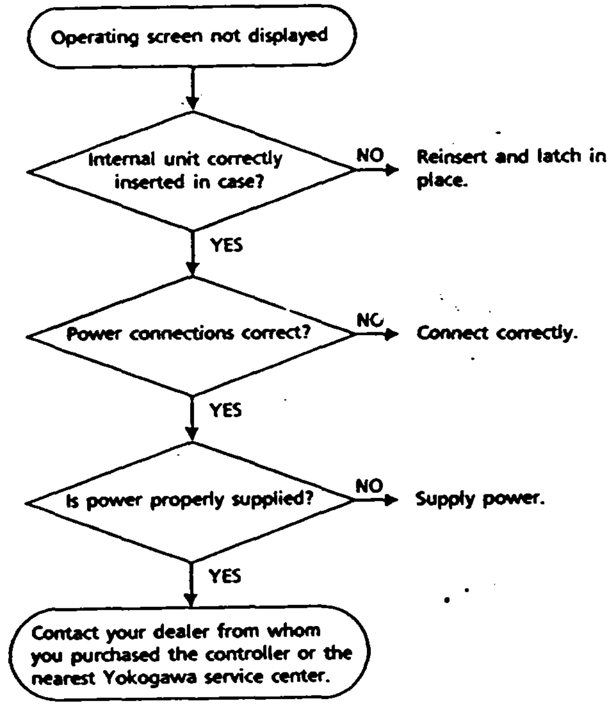
- The UT15L should normally be set up with DIP switch No.2 N.
  power is supplied the operating display panel (measured value) should appear.
- If the display goes to an "error display" condition during operation, see Section 11.2 "Error Display", and respond accordingly.
- If power is lost during operation.
  1) Momentary power outages in which power is lost for less than 20ms have no effect on UT15L operation (operation continues normally).
  2) • When power is restored (after a power outage longer than 20ms), the operation in effect immediately before power was cut is continued.
     However, if an alarm with "standby" has been selected, "standby" status goes into effect.
     • For about two seconds after power is restored, the input range code are displayed in the measured value display area.
     • Even when power is lost, values such as alarm values, etc. that have already been entered are maintained.

note : However, if power is lost while a numeric value is being set using the keys, error code E400 may be displayed in some cases. (See Section 11.2 "Error Display".)

11. MAINTENANCE

If the operating display panel is not displayed on the UT15L when power is supplied, take action according to the following troubleshooting flowchart. If a complex problem is suspected, contact your dealer or the nearest Yokogawa agent.

Troubleshooting flowchart



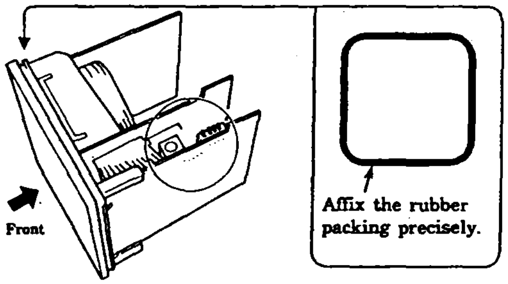
11.1 Replacement of Rubber Packing for Dustproofing

Although the life of the rubber packing for dustproofing is at least five or six years under normal operating conditions, when it deteriorates it should be replaced.

The part number and sales unit of the rubber packing are as follows. (Order from your UT15L sales representative.)

Type	Part number	Sales unit
UM05	B9877AJ	1 piece

note : Turn the power OFF when removing the internal unit.



11.2 Error Display

If any of the following are displayed, an error has been detected. Respond to these errors as indicated in by the individual "action" entries.

Error display	Description of error	Action
E000 (E000)	RAM error	Request repair
E001 (E001)	ROM error	Request repair
E002 (E002)	System data error	Request repair
E300 (E300)	A/D converter error	Request repair
E400 (E400)	Parameter entry error	Check whether any parameters are incorrect, and reenter
Undefined display	Program failure	Request repairs

Error display	Description of error	Action
Measured value (PV) decimal point flashes.	Calibration data error	Request repair.
Measured value (PV) flashes.	Non-volatile memory error	
r JC (RJC) and measured value (PV) alternately displayed	Reference junction compensation error	
b.oUt (B.OUT)	Burnout (including RTD)	Check thermocouple, RTD connections
oUr (OVR)	Over-scale	Check that measurement input range and sensor connections are correct.
-oUr (−OVR)	Under-scale	

Revision Record

July 1991 IM 5B4A7-11E New Edition
March 1994 IM 5B4A7-11E 2nd Revision
March 1996 IM 5B4A7-11E 3rd Revision

■ Documentation Conventions

The symbolic conventions below are used in this manual.

⚠ WARNING : This marking on the product indicates that the operator must exercise special care to avoid electric shock or other dangers that may result in injury or the loss of life.

YOKOGAWA ◆

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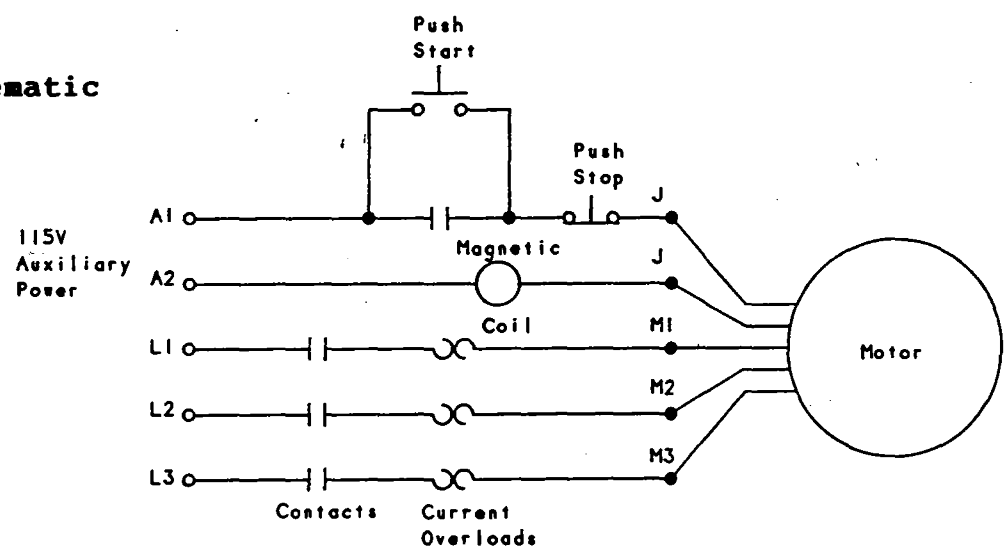
IMPORTANT: Read Before Wiring this Explosion-proof Blower

This EG&G Rotron Explosion-proof Regenerative blower is equipped with **Pilot Duty Thermal Overload protection.** When properly wired to a motor starter, this protection limits the motor winding temperature rise per the National Electric Code (NEC) article 500. Failure to properly wire this blower is a **NEC violation** and could cause an **explosion.** EG&G takes no responsibility for damages incurred by negligent use of this product, and may not warranty a blower on which the P.D.T.O. is not properly connected.

In all cases, follow the motor controller manufacturer's instructions. The following schematic is for conceptual understanding only, and may not apply to all motor controllers.

Schematic



J - Pilot Duty Thermal Overload Protection wires
L - Power leads from circut breaker box.
M - Motor leads (refer to wiring diagram inside T'box or on motor nameplate).

The above schematic is shown for a three phase motor. For a single phase motor disregard L3 and M3. Pushing the START button completes the auxiliary control circuit, allowing current to flow through the magnetic coil. The contacts are magnetically closed, starting the motor and latching the auxiliary circuit. The motor will continue to run until the STOP push button is depressed, the motor reaches the overload temperature, or the current sensing overloads trip out.

If you have any questions, EG&G Rotron Application Engineers are available at (914) 246-3401 for your assistance.

06/29/92
REV. A

POLICY REGARDING INSTALLATION OF EG&G ROTRON

REGENERATIVE BLOWERS IN HAZARDOUS LOCATIONS

EG&G Rotron will not knowingly specify, design or build any regenerative blower for installation in a hazardous, explosive location without the proper NEMA motor enclosure. EG&G Rotron does not recognize sealed blowers as a substitute for explosion proof motors. Sealed units with standard TEFC motors should never be utilized where local, state, and/or federal codes specify the use of explosion proof equipment. EG&G Rotron has a complete line of regenerative blowers with explosion-proof motors. Division I & II, Class 1, Group D; Class 2, Groups F & G requirements are met with these standard explosion-proof blowers.

EG&G Rotron offers general application guidance; however, suitability of the particular blower selection is ultimately the responsibility of the user, not the manufacturer of the blower.

EG&G

GENERAL INSTALLATION INSTRUCTIONS

EG&G ROTRON
INDUSTRIAL DIVISION

NORTH STREET
SAUGERTIES, NY 12477
PHONE: (914) 246-3401
FAX: (914) 246-3802

Rotron Regenerative Blowers

Installation Instructions for SL, DR, EN, CP, and HiE Series Blowers

1. **Bolt It Down** - Any blower must be secured against movement prior to starting or testing to prevent injury or damage. The blower does not vibrate much more than a standard electric motor.

2. **Filtration** - All blowers should be filtered prior to starting. Care must be taken so that no foreign material enters the blower. If foreign material does enter the blower, it could cause internal damage or may exit at extremely high velocity.

   Should excessive amounts of material pass through the blower, it is suggested that the cover(s) and impeller(s) be removed periodically and cleaned to avoid impeller imbalance. Impeller imbalance greatly speeds bearing wear, thus reducing blower life. Disassembling the blower will void warranty, so contact the factory for cleaning authorization.

3. **Support the Piping** - The blower flanges and nozzles are designed as connection points only and are not designed to be support members.

   Caution: Plastic piping should not be used on blowers larger than 1 HP that are operating near their maximum pressure or suction point. Blower housing and nearby piping temperatures can exceed 200° Fahrenheit. Access by personnel to the housing or nearby piping should be limited, guarded, or marked, to prevent danger of burns.

4. **Wiring** - Blowers must be wired and protected/fused in accordance with local and national electrical codes. All blowers must be grounded to prevent electrical shock. Slo-Blo or time delay fuses should be used to bypass the first second of start-up amperage.

5. **Pressure/Suction Maximums** - The maximum pressure and/or suction listed on the model label should not be exceeded. This can be monitored by means of a pressure or suction gage (available from Rotron), installed in the piping at the blower outlet or inlet. Also, if problems do arise, the Rotron Application Engineering staff will need to know the operating pressure/suction to properly diagnose the problem.

6. **Excess Air** - Bleed excess air off. DO NOT throttle to reduce flow. When bleeding off excess air, the blower draws less power and runs cooler.

Note: Remote Drive (Motorless) Blowers - Properly designed and installed guards should be used on all belts, pulleys, couplings, etc. Observe maximum remote drive speed allowable. Due to the range of uses, drive guards are the responsibility of the customer or user. Belts should be tensioned using belt gauge.

Maintenance Procedure

When properly piped, filtered, and applied, little or no routine maintenance is required. Keep the filter clean. Also, all models in the DR, EN, CP, and HiE series have sealed bearings which require no maintenance. Bearings should be changed after 15,000 to 20,000 hours, on average. Shell Dolium R grease is used at the factory. Replacement bearings should contain Shell Dolium R or its equivalent.

Troubleshooting

		POSSIBLE CAUSE	REMEDY
IMPELLER DOES NOT TURN	Humming Sound	1. * One phase of power line not connected 2. * One phase of stator winding open 3. Bearings defective 4. Impeller jammed by foreign material 5. Impeller jammed against housing or cover 6. ** Capacitor open	1. Connect 2. Contact factory 3. Change bearings 4. Clean 5. Adjust 6. Change capacitor
	No Sound	1. * Two phases of power line not connected 2. * Two phases of stator winding open	1. Connect 2. Contact factory
IMPELLER TURNS	Blown Fuse	1. Insufficient fuse capacity 2. Short circuit	1. Use fuse of proper rating 2. Repair
	Motor Overheated Or Protector Trips	1. High or low voltage 2. * Operating in single phase condition 3. Bearings defective 4. Impeller rubbing against housing or cover 5. Impeller or air passage clogged by foreign material 6. Unit operating beyond performance range 7. Capacitor shorted 8. * One phase of stator winding short circuited	1. Check input voltage 2. Check connections 3. Check bearings 4. Adjust 5. Clean 6. Contact factory 7. Change capacitor 8. Contact factory
	Abnormal Sound	1. Impeller rubbing against housing or cover 2. Impeller or air passages clogged by foreign material 3. Bearings defective	1. Adjust 2. Clean 3. Change bearings
	Performance Below Standard	1. Leak in piping 2. Piping and air passages clogged 3. Impeller rotation reversed 4. Leak in compressor 5. Low voltage	1. Tighten 2. Clean 3. Check wiring 4. Tighten cover, flange 5. Check input voltage

* 3 phase units
** 1 phase units

For further information regarding Rotron regenerative blowers (including service & parts manuals), please contact our local field sales representative. For factory assistance, contact Applications Engineering, EG&G Rotron Industrial Division.

WATLOW

Engineering Bulletin

#89.4.3

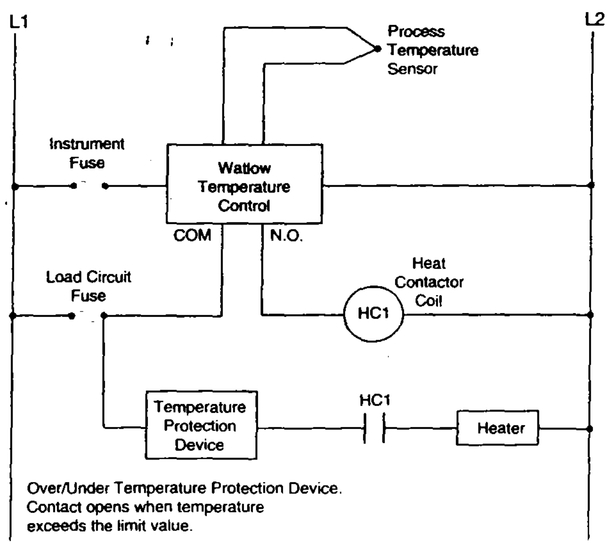
Over/Undertemperature Protection

Failure of components in a temperature control loop, such as the sensor, heater control relay, or main temperature control, can result in damage to a product in process, a meltdown of a heater, and/or a damaging fire.

To protect against this possibility, over/undertemperature protection must be provided to interrupt or remove power from the heater circuit. A "thermal fuse line" at the heater, or a "mechanical thermoswitch" at the heater are examples of recommended over/under temperature protection. For precise, repeatable limit protection, an "electronic limit control" may be used. We recommend the temperature protection device have UL, CSA, or FM approval, and be applied in the classification for which it was tested and approved. An example of a single phase wiring line diagram appears below.

WARNING

Install high or low temperature control protection in systems where an overtemperature or undertemperature fault condition could present a fire hazard or other hazard. Failure to install temperature control protection where a potential hazard exists could result in damage to equipment and property, and injury to personnel.



Further information is available from Watlow Controls; ask for application assistance.

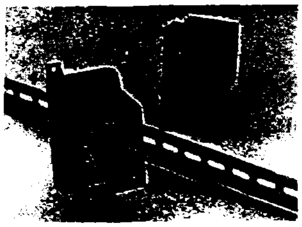
Disclaimer of Warranty

This document is a presentation of a general overview and statement of the safety-related need for and method of applying "over/undertemperature protection." Because of the diversity of conditions and hazards under which control products may be applied and because of the differences in components and methods of their installation, **no representation or warranty of any kind, express or implied, is hereby made**, that the limit control protection discussed and presented herein will be effective in any particular application or set of circumstances, or that additional or different precautions will not be reasonably necessary for a particular application. We will be pleased to consult with any customer regarding a specific application upon written request.

Watlow Controls, 1241 Bundy Blvd., P.O. Box 5580, Winona, MN 55987-5580, Ph: 507-454-5300, Fax: 507-452-4507

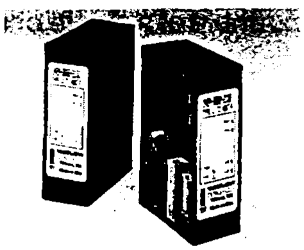
Limit Controls from Watlow

TOTAL CUSTOMER SATISFACTION



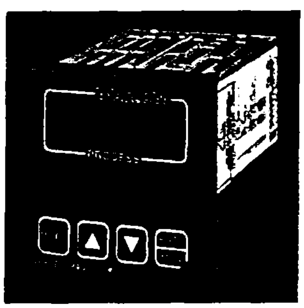
Series 92 - UL & FM Approved DIN Rail Mounted Limit

- Compact, finger/palm-safe design
- Latching limit (factory set as heat or cool) or temperature control
- Internal latching reset for a customer-supplied reset switch
- Operating environment:
  - 32 to 140°F (0 to 60°C)
  - 0 to 90% RH, non-condensing
- Agency Approvals
  - UL®873, File #E43684
  - FM 3545, J.I. ØY6A4.AF
  - CSA C22.2 #24-93, File #LR30586
  - Submitted for CE testing



Series 142 - UL Recognized Safety Limit

- Environmentally protected
- Compact sub-panel mounting
- Backup limit protection
- Factory fixed set point
- Operating environment:
  - 32 to 130°F (0 to 54°C)
  - 0 to 90% RH, non-condensing
- Agency Approvals
  - UL®197, 873, 991, File #E43684
  - CSA C22.2 #24-1987, File #LR30586
  - A.G.A., File 23-1C1



Series 945 - UL Recognized High-Low Limit

- 1/4 DIN microprocessor-based limit controller
- Wide range of input types
- Set point range limiting
- Dual limit control outputs
- Three operator lock-out levels
- Operating environment:
  - 32 to 149°F (0 to 65°C)
  - 0 to 90% RH, non-condensing
- Agency Approvals
  - UL®873 File #E43684
  - FM 3545, J.I. ØY6A4.AF

Your Authorized Watlow Distributor is:

WATLOW

Watlow Controls

1241 Bundy Blvd., P.O. Box 5580, Winona, MN 55987-5580, Ph: 507-454-5300, Fax: 507-452-4507

WLCS-XSBN Rev A00
Mar. 96

Printed on Recycled Paper

Series 965

User's Manual

Total
Customer
Satisfaction

CE

1/16 DIN
Microprocessor-Based
Auto-tuning Control

ISO 9001

Registered Company
Winona, Minnesota USA

WATLOW
Watlow Controls

Watlow Controls, 1241 Bundy Blvd., P.O. Box 5580, Winona, MN 55987-5580, Phone: 507/454-5300, Fax: 507/452-4507

W965-XUMN Rev A02
May 1996
Supersedes: W965-XUMN Rev B00 and B01

$10.00
Made in the U.S.A.
Printed on Recycled Paper

How to Use this Manual

We have designed this user's manual to be a helpful guide to your new Series 965. The headlines in the upper right and left corners indicate which tasks are explained on that page.

Notes and Safety Information

NOTE:
Details of a "Note" appear here, in the narrow box on the outside of each page.

We use notes, cautions and warnings throughout this book to draw your attention to important information.

Notes are printed in bold in the margin to alert you to an important detail.

A Caution symbol (an exclamation point in a triangle) appears with information that is important to protect equipment and performance. Read and follow all cautions that apply to your application.

CAUTION:
Details of a "Caution" appear here, in the narrow box on the outside of each page.

A Warning symbol (a lightning bolt in a diamond) appears with information that is important to protect people and equipment from damage. Pay very close attention to all warnings that apply to your application.

WARNING:
Details of a "Warning" appear here, in the narrow box on the outside of each page.

Technical Assistance

If you encounter a problem with your Watlow controller, review all of your configuration information for each step of the setup, to verify that your selections are consistent with your applications.

If the problem persists after checking all the steps, call for technical assistance: Watlow Controls at (507) 454-5300, between 7:00 a.m. and 5:30 p.m. Central Standard Time. Ask for an applications engineer. When you call, have the following information ready:

- the controller's model number (the 12-digit number is printed on the top of the stickers on each side of the controller's case and on the top or right side of the circuit board);
- this user's manual;
- all configuration information;
- the Diagnostics Menu readings.

Warranty and Returns

For information about the warranty covering the Series 965, see page 37.

Comments and Suggestions

We welcome your comments and opinions about this user's manual and the Series 965. Send them to the Technical Editor, Watlow Controls, 1241 Bundy Blvd., P.O. Box 5580, Winona, MN 55987-5580. Or call (507) 454-5300. Or fax them to (507) 452-4507.

Chapter 1

Starting Out With The Watlow Series 965, A Microprocessor-Based Control

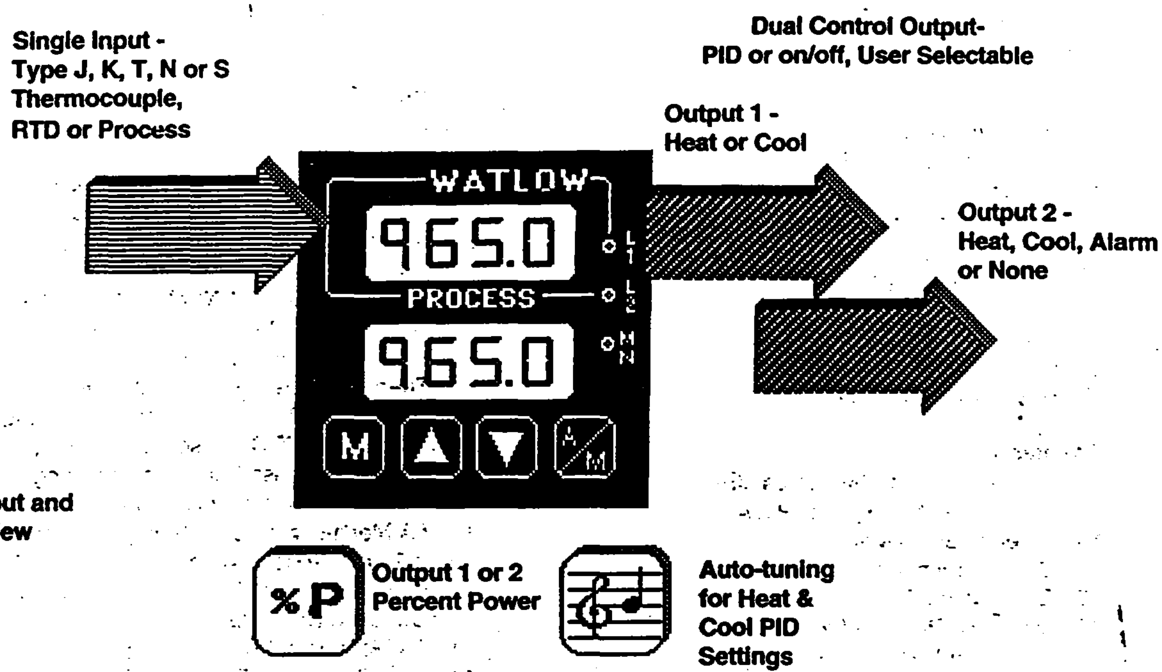


Figure 1 - Series 965 Input and Output Overview

General Description

Welcome to the Watlow Series 965, a 1/16 DIN microprocessor-based temperature control. The 965 has a single input which accepts type J, K, T, N or S thermocouple, RTD or process input.

With dual output, the primary can be heating or cooling while the secondary can be a control output opposite the primary output (heat or cool), alarm or none. Both outputs can be selected as either PID or on/off. PID settings include proportional band, reset/integral, and rate/derivative. Setting the proportional band to zero makes the Series 965 a simple on/off control with switching differential selectable under the HSC parameter.

Special 965 features include the NEMA 4X rating, dual four digit displays in either red or green, optional low volt power supply, auto-tuning for both heat and cool outputs, ramp to set point for gradual warm-up of your thermal system, and automatic/manual capability with bumpless transfer.

Operator-friendly features include automatic LED indicators to aid in monitoring and setup, as well as a calibration offset at the front panel. The Watlow Series 965 automatically stores all information in a non-volatile memory.

Install and Wire the Series 965

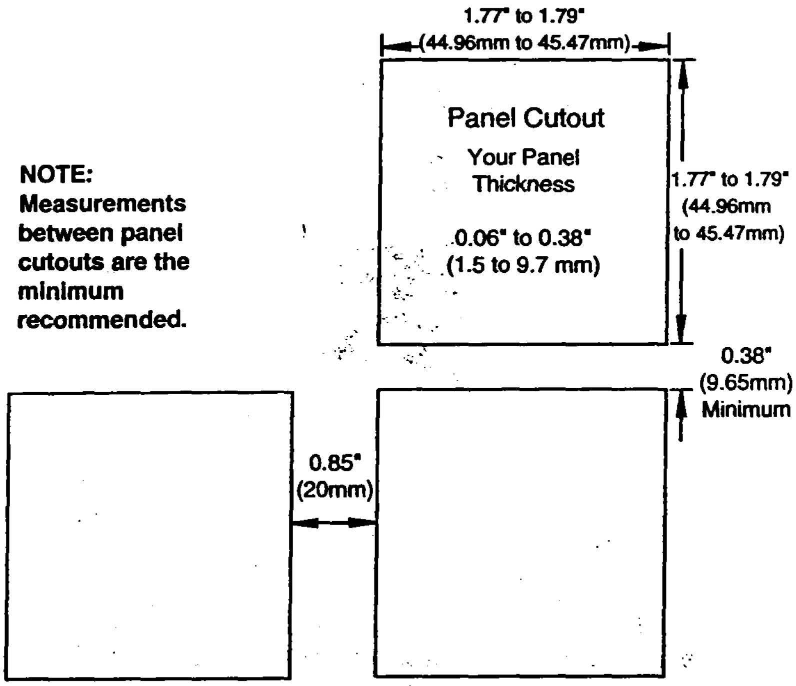


Figure 2 - Series 965 Multiple Panel Cutout Dimensions

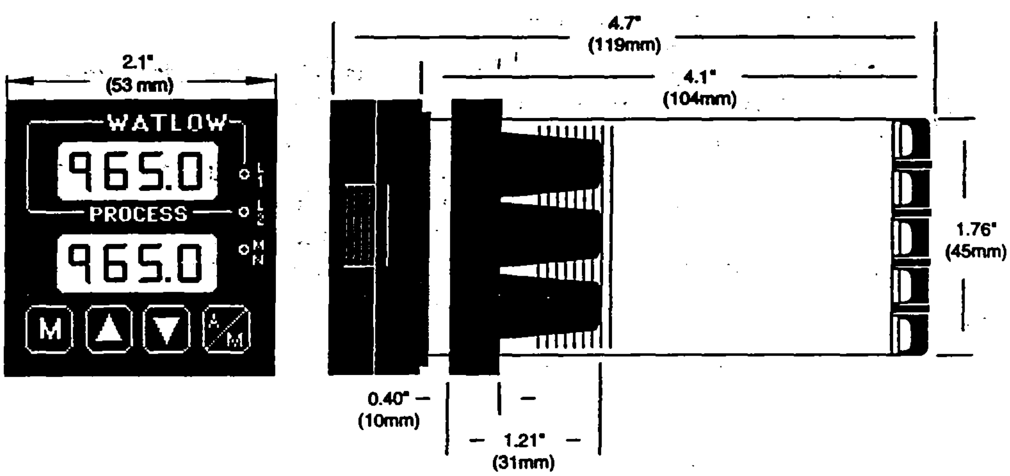


Figure 3 - Series 965 Dimensions

NOTE: For rapid mounting, use Greenlee punch #60020 and die #60021, or hand hydraulic unit, Kit #7306. All available from Grainger.

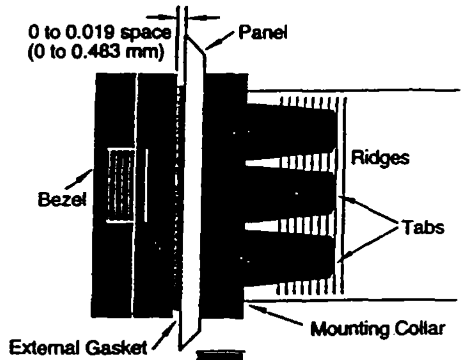
Installation Procedure

Follow this procedure to mount the Watlow Series 965 temperature control:

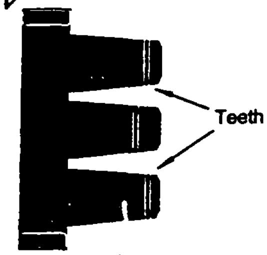
1. Make a panel cutout per the dimensions in Figure 2.
2. Remove the 965 chassis from its case. Holding each side of the bezel, press in firmly on the side grips until the tabs release. Pull the chassis out of the case and set aside for later installation.
3. Make sure the rounded side of the external case gasket is **facing** the panel surface. Check to see that the gasket is not twisted, and is seated within the case bezel flush with the panel. Place the case in the cutout you just made. Make sure the gasket is between the panel cutout and the case bezel. See Figure 4A.

Figure 4 - Mounting, Case Side View & Collar Cross Section

4A



4B



Mounting Collar Cross Section (notice the offset teeth on each tab)

4. While pressing the front of the case firmly against the panel, slide the mounting collar over the back of the control. The tabs on the collar must line up with the mounting ridges on the case for secure installation. See Figure 4A again. Slide the collar firmly against the back of the panel getting it as tight as possible. Make sure you cannot move the case within the cutout; if you can you do not have a NEMA 4X seal.

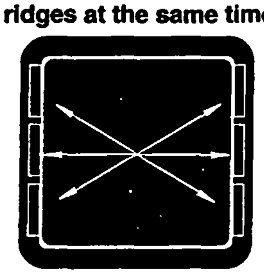
   Now let's make sure we have a tight seal. Use your thumb to lock the tabs into place while pressing the case from side to side. Don't be afraid to apply enough pressure to install the control. The tabs on each side of the collar have teeth which latch into the ridges. See Figure 4B. Each tooth is staggered at a different height, so only one of the tabs on each side are ever locked into the ridges at any time.

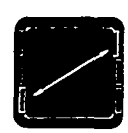
   Looking at Figure 5, you see that the tabs on one side of the collar correspond with those on the opposite side. Make sure that the two corresponding tabs are the only ones locked in the ridges at the same time. If the matching tabs are not holding the case at the same time you **will not** have a NEMA 4X seal. You can make a visual check, or use your finger nail to pull out on each tab. **Only one on each side is engaged, and they must be corresponding as in Figure 5.** The space between the bezel and panel must be between 0 and 0.019" (0.48 mm).

NOTE:
To guarantee a proper NEMA 4X seal, make sure the gasket between the panel and the rim of the case is not twisted and is seated properly.
PRESS FIRMLY.

Figure 5 - Case Rear View and NEMA 4X Seal Example

Make sure that the two corresponding tabs below are locked in the ridges at the same time.





NEMA 4X Seal Example.

When removing the mounting collar, we suggest sliding a thin tool such as a putty knife or screwdriver under all three tabs on each side at once and pulling it back off the case.

5. Insert the control chassis into its case and press the bezel to seat it. Make sure the inside gasket is also seated properly and not twisted. The hardware installation is complete. Proceed to the wiring section from here.

How to Wire the Series 965

The Series 965 wiring is illustrated by model number option. Check the unit sticker on the control and compare your model number to those shown here and also the model number breakdown in the Appendix of this manual.

All outputs are referenced to a de-energized state. The final wiring figure is a typical system example.

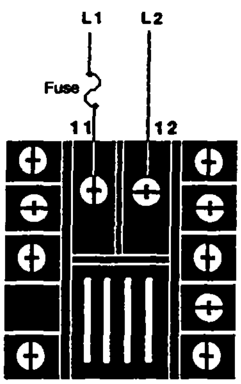
When you apply power without sensor inputs on the terminal strip, the Series 965 displays in the upper display, and a in the lower display, except for 0-5V⎓ (dc) or 4-20mA process input units. Press the A/M key twice, and is displayed for one second. This error indicates an open sensor or A/D error. To remove power to the control and connect the sensor properly, see page 8 and 9. All wiring and fusing must conform to the National Electric Code and to any locally applicable codes as well.

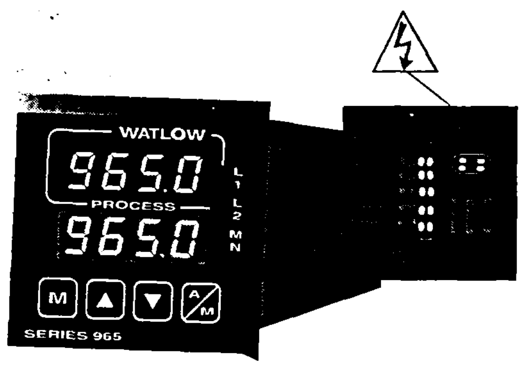
WARNING:
To avoid potential electric shock, use National Electric Code (NEC) safety practices when wiring and connecting this unit to a power source and to electrical sensors or peripheral devices.

High Voltage

Model # 965A - 3 _ _ 0 - 00 _ _

100 to 240 V~ (ac), nominal (85 to 264 actual)





WARNING:
Hazardous high voltage may still exist at some internal terminal case connections if the controller is removed from its case.

Figure 6 and 6a - High Voltage Power Wiring

Low Voltage

Model # 965A - 3 _ _ 1 - 00 _ _

12-24V≂ (ac/dc)

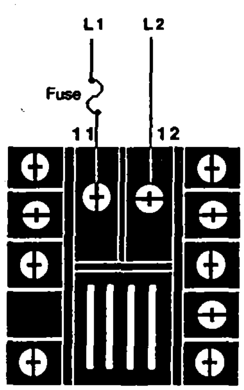


Figure 7 - Low Voltage Power Wiring

WARNING:
If high voltage is applied to the low voltage unit, irreversible damage will occur.

Sensor Installation Guidelines

We suggest you mount the sensor at a location in your process or system where it reads an average temperature. Put the sensor as near as possible to the material or space you want to control. Air flow past this sensor should be moderate. The sensor should be thermally insulated from the sensor mounting.

See Chapter 4 for more information on DIP switch location and orientation.

Thermocouple Input

NOTE: When an external device with a non-isolated circuit common is connected to the 4-20mA or dc output, you must use an isolated or un-grounded thermo-couple.

Extension wire for thermocouples must be of the same alloy as the thermo-couple itself to limit errors.

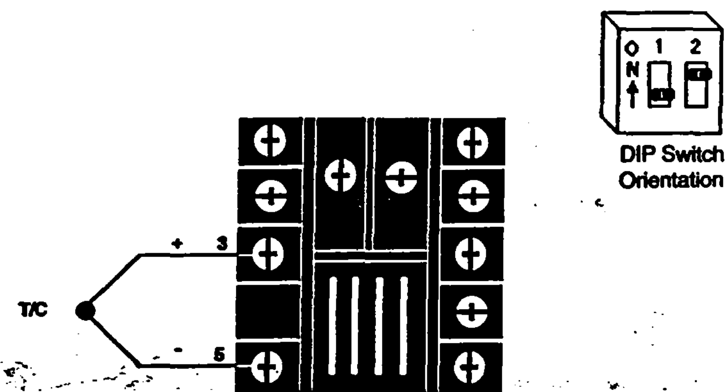
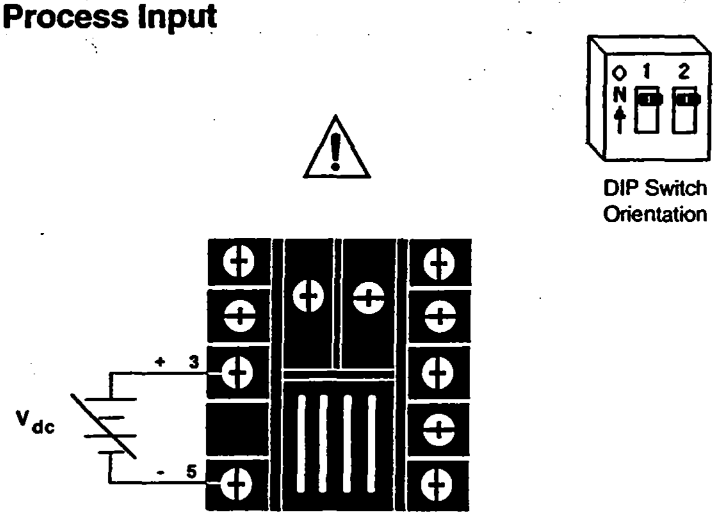


Figure 8 - Thermocouple Sensor Input Wiring

CAUTION: Process input does not have sensor break protection. Outputs can remain full on.

0-5V⎓ (dc) Process Input

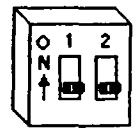


Input Impedance: 10KΩ

Figure 9 - 0-5V⎓ (dc) Process Sensor Input Wiring

RTD, 2- or 3-wire

There could be a + 2°F input error for every 1Ω of lead length resistance when using a 2-wire RTD. That resistance, when added to the RTD element resistance, will result in erroneous input to the instrument. To overcome this problem, use a 3-wire RTD sensor, which compensates for lead length resistance. When extension wire is used for a 3-wire RTD, all wires must have the same electrical resistance (i.e. same gauge, copper stranded, same length).



DIP Switch Orientation

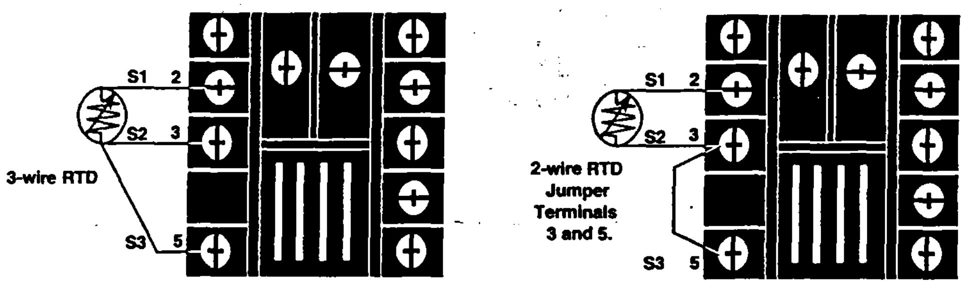
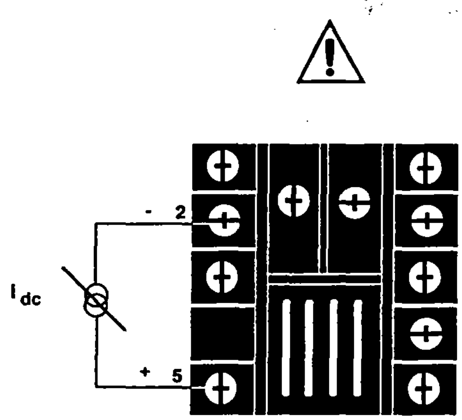
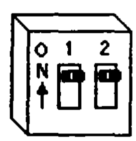


Figure 10 - 2- or 3-wire RTD · Sensor Input Wiring

4 - 20mA Process Input



Input Impedance: 5Ω



DIP Switch Orientation

CAUTION: Process input does not have sensor break protection. Outputs can remain full on.

Figure 11 - 4-20mA Process Sensor Input Wiring

Output 1 Wiring

Switched DC Output

Model # 965A - 3 C _ _ - 00 _ _

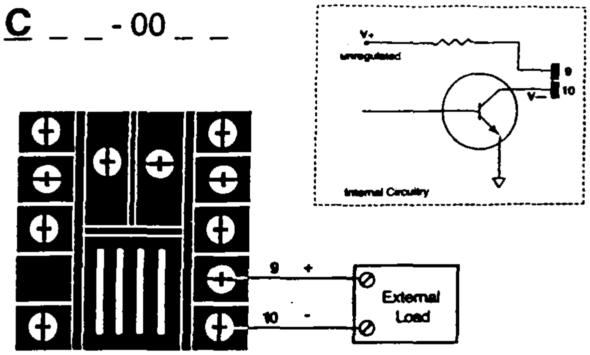


Figure 12 - Switched dc Output Wiring

NOTE: When an external device with a non-isolated circuit common is connected to the 4-20mA or Switched dc output, you must use an isolated or un-grounded thermo-couple.

Mechanical Relay Without Contact Suppression, Form C, 5 Amp

Model # 965A - 3 D _ _ - 00 _ _

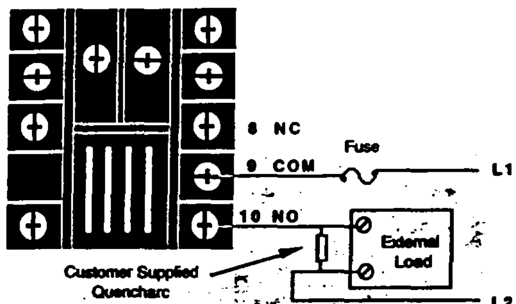
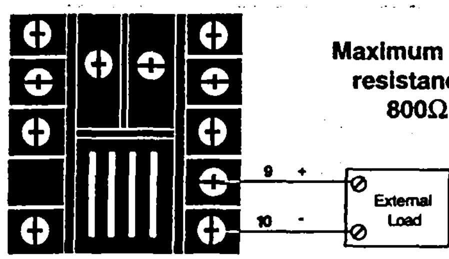


Figure 13 - 5 Amp Mechanical Relay Wiring

NOTE: Switching inductive loads (relay coils, solenoids, etc.) with the mechanical relay, switched dc or solid-state relay output options requires using an R.C. suppressor. Watlow carries the R.C suppressor Quencharc brand name, which is a trademark of ITW Pakron. Watlow Part No. 0804-0147-0000.

Process, 4-20mA

Model # 965A - 3 F _ _ - 00 _ _



Maximum load resistance: 800Ω

Figure 14 - 4-20mA Process Wiring

Solid-state Relay Without Contact Suppression, 0.5 Amp

Model # 965A - 3 K _ _ - 00 _ _

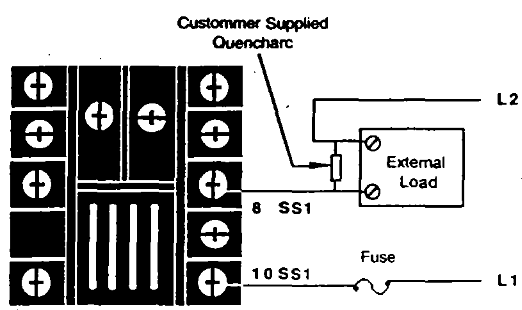
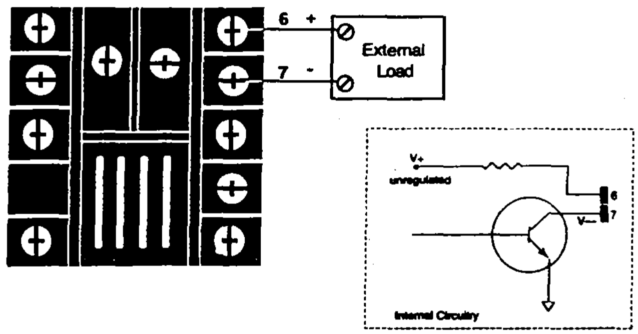


Figure 15 - 0.5 Amp Solid-state Relay Without Contact Suppression Wiring

Switched DC Output

Model # 965A - 3 _ C _ - 00 _ _



NOTE:
For more information on alarms see page 24.

Figure 16 - Switched dc Output Wiring

Mechanical Relay Without Contact Suppression, Form C, 5 Amp

Model # 965A - 3 _ D _ - 00 _ _

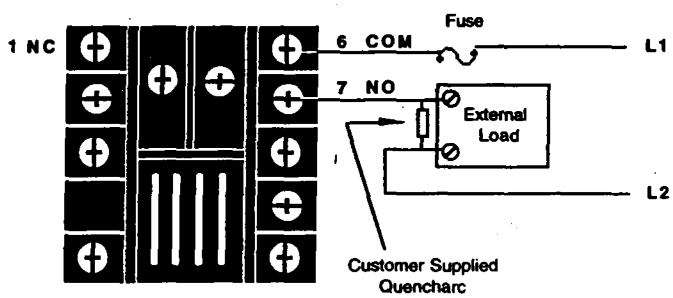
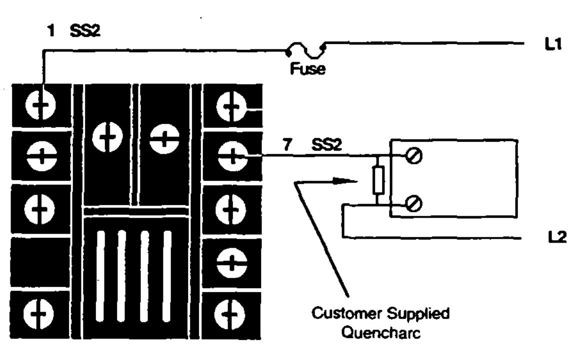


Figure 17 - 5 Amp Mechanical Relay Wiring

NOTE:
Switching inductive loads (relay coils, solenoids, etc.) with the mechanical relay, switched dc or solid-state relay output options requires using an RC suppressor. Watlow carries the RC suppressor Quencharc brand name, which is a trademark of ITW Pakron. Watlow Part No. 0804-0147-0000.

Solid-state Relay Without Contact Suppression, 0.5 Amp

Model # 965A - 3 _ K _ - 00 _ _



NOTE:
Output is in open State in Alarm Condition.

Figure 18 - 0.5 Amp Solid-state Relay Without Contact Suppression Wiring

Wiring Example

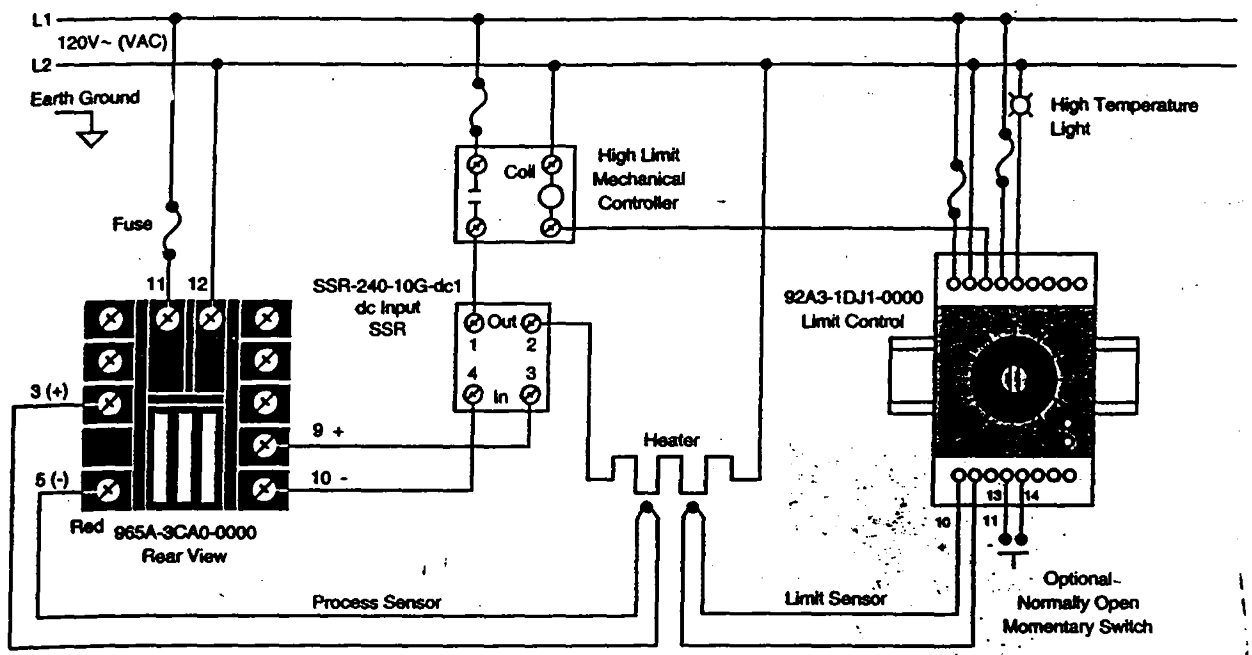
Figure 19 -
System Wiring
Example

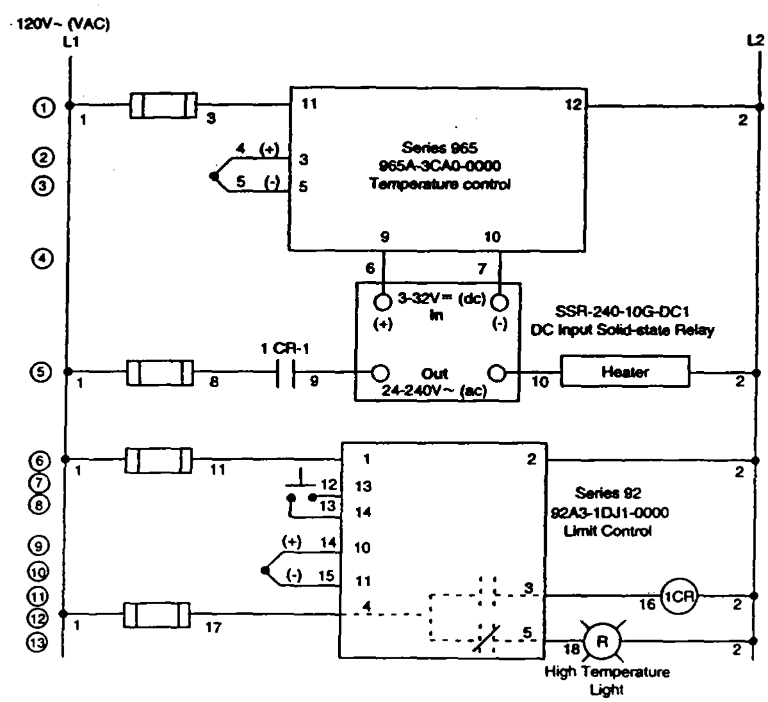
WARNING:

All wiring and fusing must conform to the National Electric Code NFPA70. Contact your local board for additional information. Failure to observe NEC safety guidelines could result in injury to personnel or damage to property.

CAUTION:

Watlow mercury relay loads must have a unity power factor.
For RESISTIVE LOADS ONLY.





965A-3CA0-0000

1 Not Used
2 S1, I-
3 S2, TC+, V+
4 Not Used
5 S3, TC-, V-, I+
6 Not Used
7 Not Used
8 Not Used
9 DC +1
10 DC -1
11 L1
12 L2

Chapter 3

How to Use the Keys and Displays

After one minute with no key activations, the control reverts to the process value in the upper display and the set point in the lower display.

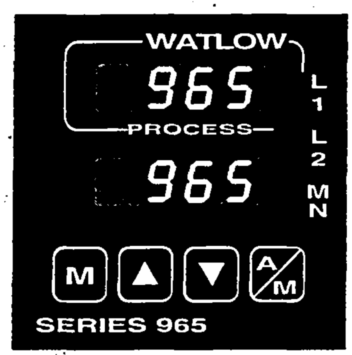
Figure 20 - Series 965 Keys and Displays

Upper Display
Red or green, 0.3" (8 mm) high, seven segment, four digit LED display, indicating either process, actual temperature, the operating parameter values or an open sensor. When powering up, the Process display will be blank for five seconds. This display can be blank by setting dSP to SEt. See page 17.

L1
When lit, this LED tells you when Output 1 is energized.

L2
When lit, this LED tells you when Output 2 is active. This output can be configured as a control or alarm output.

Lower Display
Red or green, 0.3" (8 mm) high, seven-segment, four-digit LED display, indicating the set point, output value, parameters for data in the upper display, or error and alarm codes. This display can be blank by setting dSP to Pro. See page 17.



MN
Lit when the control is in Manual operation. Press the A/M key twice to enter Automatic operation. When blinking, this indicates that pressing the A/M key toggles between Auto and Manual. After five seconds without pressing the A/M key, the LED stops blinking, and returns to its previous state.

Mode Key
Steps the control through the Operating Menu; also, in the Auto mode, new data is self entering in five seconds.

Up-arrow Key
Increases the value of the displayed parameter. A light touch increases the value by one. Holding the key down increases the value at a rapid rate. New data is self entering in five seconds.

Down-arrow Key
Decreases the value of the displayed parameter. A light touch decreases the value by one. Holding the key down decreases the displayed value at a rapid rate. New data is self entering in five seconds.

A/M Key
Pressed once, it clears any latched alarms and toggles between Auto and Manual mode. If pressed again within five seconds it will change from Auto to Manual or vice versa. While in Manual mode, percent power is in the lower display.

Up-arrow/Down-arrow Keys
When pressed simultaneously for three seconds, the Setup Menu appears displaying the LOC parameter. Continue to press the Up-arrow/Down-arrow keys, and the Calibration Menu appears.

Chapter 4

How To Set Up The Series 965

Setting up the Series 965 is a simple process. First set the DIP switches to match your input type. Refer to the orientation below and Page 16 for the In parameter. Next, configure the 965's features to your application in the Setup Menu, then enter values in the Operating Menu. Both tasks use the MODE key to move through the menus and the Up-arrow/Down-arrow keys to select data.

Before entering information in the Setup menu, set the dFL parameter.
If selected as US: °F, proportion band in degrees, reset rate are the defaults.
If selected as SI: °C, proportional band in % of span, derivative and integral are the defaults. **Changing the dFL prompt will set parameters to their factory default. Document all current parameter settings first.** See Appendix 2 in the calibration section to change this parameter.

How to Set the Input Type DIP Switch

WARNING:
Remove power from the control before removing the chassis from the case or changing the DIP switches.

The Series 965 input type can be user selectable at any time via a Dual In-line Package (DIP) switch inside the control, located on the left (viewed from the bottom). To set the DIP switch, remove the control chassis from the case. Holding each side of the bezel, press in firmly on the side grips until the tabs release. You may need to rock the bezel back and forth several times to release the chassis.

The locations of the board and switches appear in Figure 21. Refer to the input types below for DIP switch orientation. DIP switch selection must match the sensor selected under the In parameter in the Setup Menu. Set the software selection for the input type to match. See Page 16.

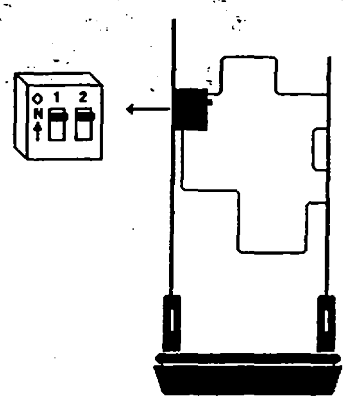
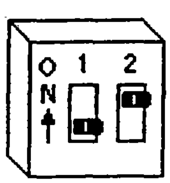


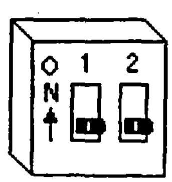
Figure 21 -
DIP Switch Location and Orientation

Input Types

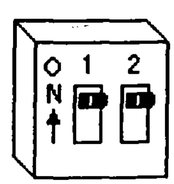
Thermocouple



RTD



Process



Entering the Setup Menu

The Setup Menu displays the parameters that configure the Series 965's features to your application.

Enter the Setup Menu by pressing the Up-arrow and Down-arrow keys simultaneously for 3 seconds. The lower display shows the LOC parameter, and the upper display shows its current level. All keys are inactive until you release both keys. You can reach the LOC parameter from anywhere.

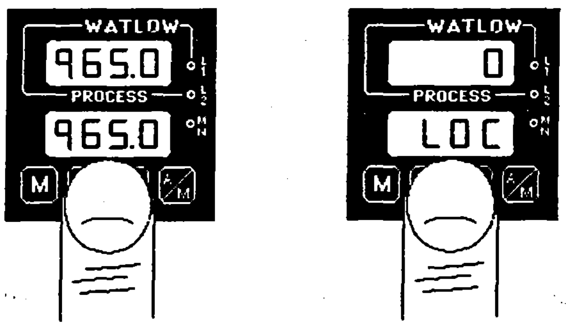
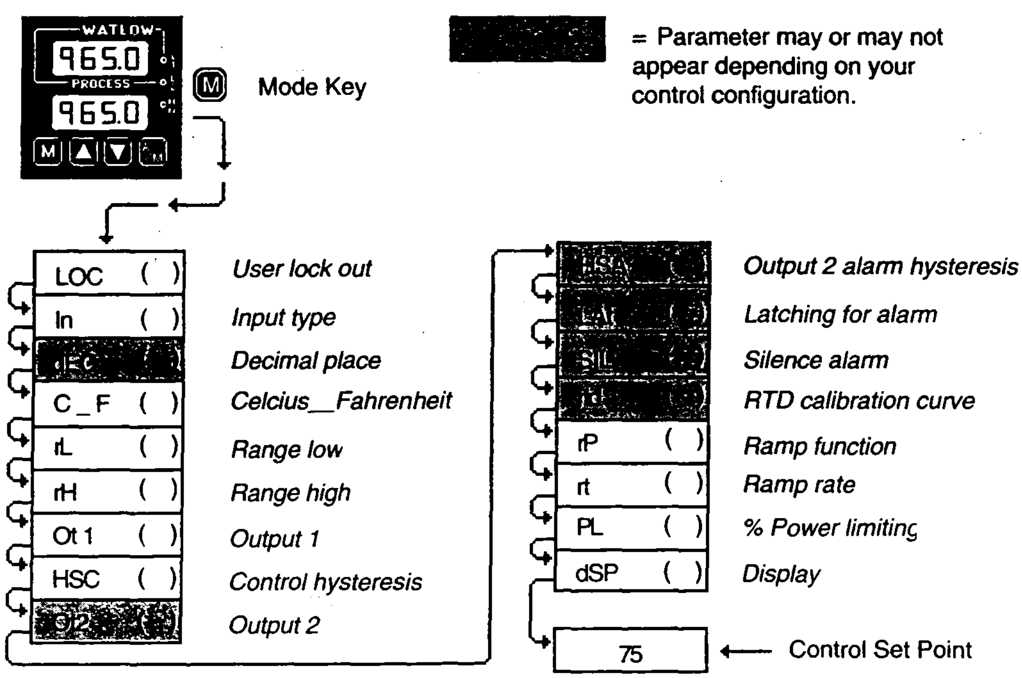


Figure 22 - Entering the Setup Menu

You will not see all parameters in this menu, depending on the unit's configuration and model number. After stepping through the menu it returns to the control set point parameter under the Operation Menu.



NOTE:
While in the Setup Menu, all outputs are off.

Figure 23 - The Setup Menu

Setup Parameters

When you are at the top of the menu, the Series 965 displays the user level of operation in the upper display, and the LOC parameter in the lower display.

Press the MODE key and the value of the next parameter appears in the upper display, and the parameter appears in the lower display.

NOTE:
Set the LOC parameter value as the final step in programming the Series 965 controller to prevent locking yourself out of the Operations and Setup Menu during initial programming.

NOTE:
Process input does not have sensor break protection or bumpless transfer.

LOC

Lock: Selects the level of operator lock-out as defined below.
Range: 0 - 4 **Default:** 0

LOC 0: All operating parameters may be viewed or changed. Manual operation is permitted. When in manual operation, percent power is adjustable. Bumpless transfer to manual mode can occur on sensor break.

LOC 1: The set point, actual, and alarm settings are the only visible parameters, set point is adjustable in this level. Manual operation and auto-tune are permitted. When in manual operation, percent power is adjustable. Bumpless transfer to manual mode can occur on sensor break.

LOC 2: The set point, actual, and alarm settings are the only visible parameters, set point is adjustable in this level. Manual operation is permitted. When in manual operation, percent power is adjustable. Bumpless transfer to manual mode can occur on sensor break.

LOC 3: The set point and actual are the only visible parameters, set point is adjustable in this level. Manual operation is not permitted. Bumpless transfer is defeated and outputs are disabled on sensor break.

LOC 4: The set point and actual are the only visible parameters, set point is not adjustable in this level of lock-out. Manual operation is not permitted. Bumpless transfer is defeated and outputs are disabled on sensor break.

In

Input: Selects the sensor input type. The internal DIP switch must also match the In parameter. See Page 14 for DIP switch orientation, and see Page 18 for input type temperature ranges.
Range: J, K (appears as H), t, n, S, rtd, rt.d, 0-5, 420 **Default:** J

dEC

Decimal: Selects the location of the decimal point for all process related data. This parameter only appears if the In parameter is 0-5 or 420. Make sure the internal DIP switch matches the In parameter.
Range: 0, 0.0, 0.00 **Default:** 0

C_F

Celsius _ Fahrenheit: Selects the units of temperature measurement for the control. This parameter only appears if the In parameter is a thermocouple or RTD input. The default is dependent on the dFL parameter located in the Calibration menu. Refer to the Appendix. **Range:** C or F
If dFL = US: **Default:** F If dFL = SI: **Default:** C

rL

Range Low: Selects the low limit of the set point. Also used to set the low end of the process input. 0.0V= (VDC) and 4mA represent Range Low (rL) for process input. The process input is linearly scaled between rL and rH. See the model number and specification in the Appendix for range values, or refer to Table 1 on Page 18. **Range:** Sensor range low to rH
Default: Low limit of sensor type/-500 for process input

Range High: Selects the high limit of the operating range. Also used to set the high end of the process input. 5.0V⎓ (dc) and 20mA represent Range High (rH) for process input. The process input is linearly scaled between rL and rH. See the model number and specification information in the Appendix for your range values, or refer to Table 1 on Page 18. **Range:** Sensor range high to rL **Default:** High limit of sensor type/9999 for process input

rH

Output 1: Selects the action for the primary output. Action in response to the difference between set point and process variable. Select ht (heat) for reverse acting or select CL (cool) for direct acting. **Range:** ht, CL **Default:** ht

Ot1

Hysteresis-Control: Selects the switching hysteresis for Output 1 and 2 when you select 0 (ON/OFF) under the Pb1 parameter and Ot2 = Con.
Range: 1 to 99, 0.1 to 9.9, 0.01 to 0.99/1 to 55, 0.1 to 5.5, 0.01 to 0.55
Default: 3, 0.3, 0.03°F/2, 0.2, 0.02

HSC

Output 2: Selects the output action for the secondary output.

Range:	Con	Control mode opposite Output 1 (heat or cool) **Default:** Con
	PrA	Process alarm with alarm message displayed
	Pr	Process alarm with no alarm message displayed
	dEA	Deviation alarm with alarm message displayed
	dE	Deviation alarm with no alarm message displayed
	no	None

Ot2

Hysteresis - Alarm: Selects the switching hysteresis for Output 2 when Ot2 is an alarm. This parameter only appears if Ot2 ≠ Con or no. See Page 19 for the Pb1 parameter. **Range:** 1 to 9999, 0.1 to 999.9, 0.01 to 99.99/1 to 5555, 0.1 to 555.5, 0.01 to 55.5 **Default:** 3, 0.3, 0.03/2, 0.2, 0.02

HSA

Latching: Selects whether the alarm is latching or non-latching. Latching alarms must be cleared before the alarm output will reset. Non-latching automatically resets the alarm output when the condition clears. This parameter will not appear if Ot2 = Con or no. **Range:** LAt or nLA **Default:** nLA

LAt

Silencing: Selects alarm silencing (inhibit) for the alarm. This parameter appears only when Ot2 = dEA or dE. For more information see Chapter 5, "Using Alarms."
Range: On or OFF **Default:** OFF

SIL

RTD: Selects the RTD calibration curve for RTD inputs. This parameter will not appear unless In = rtd or rt.d. JIS = 0.003916Ω/Ω°C, DIN = 0.003850Ω/Ω°C. **Range:** din or JIS **Default:** din

rtd

Ramping: Choose **Str**, and the set point ramps at the selected rate in °/hr from process (actual) temperature to set point, when power is applied to the control (start up). It will not ramp with a set point change. **On** is the same as Str plus it ramps *with* a set point change. It ramps from the previous set point to a new one at the selected ramp rate. **OFF** is for no ramping action. When ramping, the lower display alternately flashes rP. The set point displayed is the desired end set point. The ramping setpoint is not shown. Entering the Setup menu or manual operation disables the outputs and ramp. Once you exit either one, the 965 controls to the last entered set point. **Range:** Str, On, OFF **Default:** OFF

rP

Rate: Selects the ramping rate in degrees per hour. This parameter will not appear if rP = OFF. **Range:** 0 to 9999 **Default:** 100°/hr

rt

P L

Power Limiting: The power limiting function in % power for heat.
Range: Dependent on output type. -100 to100 **Default:** 100

dSP

Display: Selects which displays are active or viewable. Five seconds after selected, the appropriate display goes blank. Press MODE, Up-arrow or Down-arrow to override this feature and cause the current value to be displayed for 5 seconds.

Range: nor Normal displays **Default:** nor
SEt Set Point - Lower display only
Pro Process - Upper display only

Table 1 - Input Ranges.

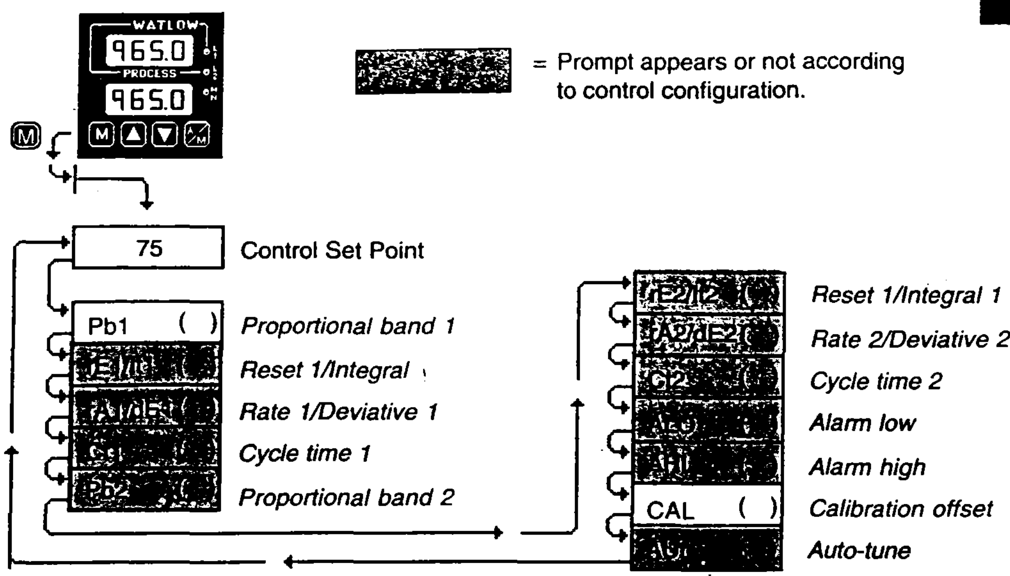
Input Type	Sensor Range Low	Sensor Range High
J	32°F/0°C	1382°F/750°C
K (appears as H)	-328°F/-200°C	2282°F/1250°C
t	-328°F/-200°C	662°F/350°C
n	32°F/0°C	2282°F/1250°C
S	32°F/0°C	2642°F/1450°C
rtd (1°)	-328°F/-200°C	1292°F/700°C
rt.d (0.1°)	-199.9/199.9	999.9/700.0
4-20mA	4mA/-999 units	20mA/9999 units
0-5V⎓ (dc)	0V⎓ (dc)/-999 units	5V⎓ (dc)/9999 units

Table 2 - Setup Menu Prompts and Descriptions.

Setup Menu

Do not enter any values here; make photocopies instead.

Parameter	Value	Range	Factory Default	Appears If:
LOC		0 - 4	0	
In		J, K (appears as H), t, n, S, rtd, rt.d, 0-5, 420	J	DIP switch selectable.
dEC		0, 0.0, 0.00	0	In = 0-5 or 420
C _ F		C or F	Dependent on dFL.	In = J,K,t,n,S,rtd,rt.d
rL		rL to rH	Input dependent.	
rH		rH to rL	Input dependent.	
Ot1		ht or CL	ht	
HSC		1 - 99, 0.1 - 9.9, 0.01 - 0.99 1 to 55, 0.1 to 5.5, 0.01 to 0.55	3, 0.3, 0.03 3, 0.3, 0.03/2, 0.2, 0.02	
Ot2		Con = Control PrA = Process Alarm Pr = Process with no alarm message dEA = Deviation alarm dE = Deviation with no alarm message no = None	Con	
HSA		1 - 9999, 0.1 - 999.9, 0.01 - 99.99 1 - 5555, 0.1 - 555.5, 0.01 - 55.55	3, 0.3, 0.03°F 2, 0.2, 0.02°C	Ot2 ≠ Con or no
LAt		LAt or nLA	nLA	Ot2 ≠ Con or no
SIL		On or OFF	OFF	Ot2 = dEA or dE
rtd		JIS or din	din	In = rtd or rt.d
r P		Str = Ramping on power up on = Ramping to set point at all times OFF = None	OFF	
rt		0 to 9999	100°/hr	rP ≠ OFF
P L		0 to 100	100	
dSP		nor = normal SEt = Set Point (lower only) Pro = Process (upper only)	nor	



NOTE:
The upper display will always return to the process value after 1 minute without key strokes.

Figure 24 - The Operation Menu.

Operation Parameters

Set Point: Sets the operating set point for Output 1. Represents the process value the system tries to achieve for Output 1. "SP" does not appear, the control set point **value** will. The lower display may be blank if dSP = Pro. If in a ramping mode, the lower display alternately flashes the desired end set point and rP.

[SP]

Proportional Band 1 & 2 : A proportional band expressed in degrees or % of span, within which a proportioning function is active for Output 1 or 2. When Pb1 = 0, the unit functions as an on/off control on Output 1 and 2. Pb2 will not appear if Pb1 = 0 or Ot2 ≠ Con. The switching differential is determined by the HSC parameter.
If dFL = US: **Range** Pb1: 0 to 999°F/0 to 555°C/0 to 999 Units; 0.0 to 9.9°F/ 0.0 to 5.5°C/0.0 to 9.9 units, Pb2: The same as Pb1 except lower limit is 1.
Defaults: *Pb1* = 25°F/2.5°F *Pb2* = 25
If dFL = SI: **Range:** 0 to 999.9% of span **Defaults:** *Pb1* = 3.0% *Pb2* = 3.0%

Pb1
Pb2

Reset /Integral 1 & 2: An integral control action for Output 1 or 2 that automatically eliminates offset, or "droop," between set point and actual process temperature. rE1/It1: Will not appear if Pb1 = 0. rE2/It2: Appears if Pb1 ≠ 0 and Ot2 = Con. Either reset (rE) or integral (It) will appear depending on how the dFL parameter is set in the Calibration menu. See Appendix II.
If dFL = US: **Range:** 0 to 9.99 repeats/minute **Default:** 0.00
If dFL = SI: **Range:** 00.1 to 9.99 minutes per repeat **Default:** 0.00

rE1/It1
rE2/It2

Rate /Derivative 1 & 2 : The rate (derivative) function for Output 1 or Output 2. Eliminate over shoot on start up, or after the set point changes. rA1/dE1: Will not appear if Pb1 = 0. rA2/dE2: Appears if Pb1 ≠ 0 and Ot2 = Con. Either rate (rA) or derivative (dE) appears depending on how dFL is set in the Calibration menu. If dFL = US or SI: **Range:** 0 to 9.99 minutes **Default:** 0.00

rA1/dE1
rA2/dE2

Cycle Time 1 & 2: Time for a controller to complete one time proportioned cycle for Output 1 or Output 2; expressed in seconds. Ct1: Will not appear if Pb1 = 0, or Output 1 is 4-20mA. Ct2: Will not appear if Pb1 = 0 or Ot2 ≠ Con. **If a mechanical relay or contactor is switching power to the load, a longer cycle time may be desirable to minimize wear on the mechanical components. Typical life of a mechanical relay is 100,000 cycles.**
Range: 0.1 to 999.9 **Default:** 5.0

Ct1
Ct2

ALO

Alarm Low: Represents the low process alarm or low deviation alarm. This parameter will not appear if Ot 2 = no or Con.
If Ot2 = dEA or dE: **Range:** -999 to 0 **Default:** -999
If Ot2 = PrA or Pr: **Range:** rL to AHI **Default:** rL

AHI

Alarm High: Represents the high process alarm or high deviation alarm. This parameter will not appear if Ot2 = no or Con.
If Ot2 = dEA or dE: **Range:** 0 to 999 **Default:** 999
If Ot2 = PrA or Pr: **Range:** ALO to rH **Default:** rH

CAL

Calibration Offset: Adds or subtracts degrees from the input signal.
Range: -180°F to 180°F/-100°C to 100°C/-180 units to 180 units; or -18.0°F to 18.0°F/-10.0°C to 10.0°C **Default:** 0

AUt

Auto-Tune: Initiates auto-tune.
Range: 0 = off, 1 = slow, 2 = medium, 3 = fast **Default:** 0

Table 3 - Operation Menu Prompts and Descriptions.

Operation Menu

Use this page as a master copy for your Series 965 Operation Parameters. **Do not enter any values here; make photocopies instead.**

Operation Parameters	Value	Range	Factory Default
Pb1		If dFL = US: 0 - 999°F/0 - 555°C/0 - 999 Units 0 - 99.9°F/0 - 55.5°C/0 - 99.9 Units 0=ON/OFF control. HSC =switch diff. If dFL = SI: 0.0 to 999.9% of span	 25°F 2.5°F 3%
rE1		0.00 to 9.99 repeats/minute 0.00 = No Reset. Won't appear if Pb1 = 0 or dFL = SI.	0.00 repeats/minute
It1		0.0 - 99.9 minutes/rpt. 0.00 = No Integral. Won't appear if Pb1 = 0 or dFL = US.	00.0 minutes/repeat
rA1		0.00 to 9.99 minutes 0.00 = No Rate. Will not appear if Pb1 = 0 or dFL = SI.	0.00 minutes
dE1		0.00 - 9.99 minutes. 0.00 = No Derivative. Won't appear if Pb 1 = 0 or dFL = US.	0.00 minutes
Ct1		0.1 to 999.9 Won't appear if Pb1 = 0, or 4-20mA.	5.0 seconds
Pb2		Same as Pb1. Pb2 lower limit = 1, 0.1, 0.01	
rE2		Same range as rE1.	
It2		Same range as It1.	
rA2		Same range as rA1.	
dE2		Same range as dE1.	
Ct2		Same range as Ct1.	
ALO - Deviation dE Process Pr		-999 to 0 rL to AHI Will not appear if Ot2 = no or Con.	-999 rL
AHI - Deviation dE Process Pr		0 to 999 ALO to rH Will not appear if Ot2 = no or Con.	999 rH
CAL		±18°F/±10°C/±18 Units	0
AUt		0-3	0

Chapter 5

How to Tune and Operate

NOTE:
Set the HSC parameter under the Setup Menu to 3°F/2°C before auto-tuning your control.

Auto-tuning (Heat and/or Cool)

The Series 965 can automatically tune the PID parameters to fit the characteristics of your particular thermal system.

The auto-tuning procedure operates on a thermal response value — slow, medium, or fast. Use the slow thermal response when your process does not need to reach set point too rapidly, or if it usually does not often exceed set point. A fast thermal response produces a rapid temperature change over a short period of time.

Once the auto-tune sequence has begun, the Output 1 heat proportional band is set to 0 and the control goes into an on/off mode of control at 90% of the established set point. The displayed set point remains unchanged.

Once the control finishes "learning" the system, it returns to a standard PID control with the PID values automatically set as a result of auto-tuning. See Manual Tuning on the next page to set the cool PID parameters. Any change of the set point, while in auto-tune, re-initiates the auto-tune procedure.

Auto-tuning at a Set Point of 200°F

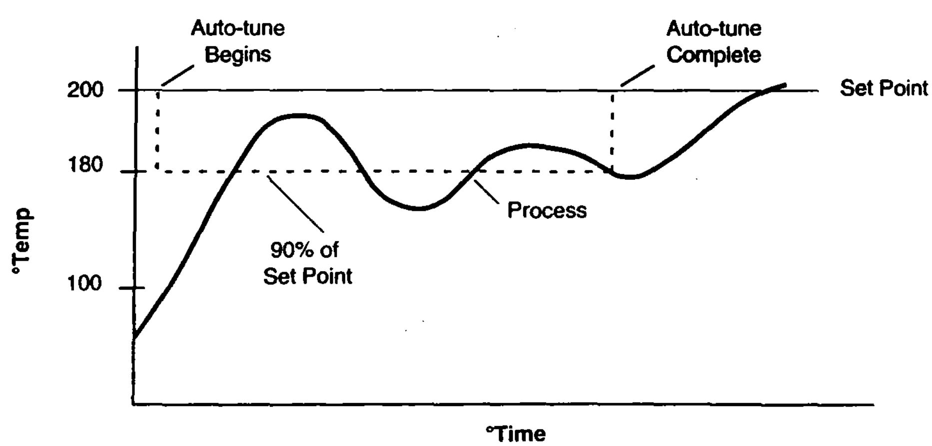


Figure 25 - Auto-tuning at a Set Point of 200°F.

In order for the 965 to successfully complete auto-tune, the process must cross 90% of set point four times within 80 minutes after auto-tune has started. If this does not happen within the 80 minute time limit, the Pb remains at 0 and the control functions in an on/off mode.

To start auto-tuning:

1. **Press the MODE key** until the **AUt** prompt appears in the data display.

2. **Select a thermal response value,** 1=slow, 2=medium, and 3=fast, using the Up-arrow/Down-arrow keys. A thermal response value of 2 satisfactorily tunes most thermal systems.

3. **Press the MODE key.** While the control is in the tuning mode, the lower display alternately displays the normal information and the prompt **At**. The time between alternations is 1 second.

4. **When tuning is complete,** the displays return to their previous state and **AUt** reverts to 0. The 965 installs appropriate PID tuning parameters and saves them in the non-volatile memory. **If a mechanical relay or contactor is switching power to the load, a longer cycle time may be desirable to minimize wear on the mechanical components. Typical life of a mechanical relay is 100,000 cycles.**

To abort auto-tuning either reset the **AUt** parameter to 0, press the A/M key twice, or cycle power off and on. In all cases, aborting auto-tune restores all values to those previous to auto-tuning.

Manual Tuning

For optimum control performance, tune the Series 965 to your thermal system. The tuning settings here are for a broad spectrum of applications; your system may have somewhat different requirements. **NOTE: This is a slow procedure, taking from minutes to hours to obtain optimum value.**

NOTE:
Tune heating outputs at a set point above ambient temperature.
Tune cooling outputs at a set point below ambient temperature.

1. **Apply power to the Series 965** and enter a set point. Begin with these Operation parameters: **Pb** = **1**, **rE/It** = 0.00, **rA/dE** = 0.00, **Ct** = 5.0, **CAL** = 0, **AUt**= 0.

2. **Proportional Band Adjustment**: Gradually increase **Pb** until the upper display temperature stabilizes to a constant value. The process temperature will not be right on set point because the initial reset value is 0.00 repeats per minute. (When **Pb** = 0; **rE/It** and **rA/dE1** are inoperative, and the 965 functions as a simple ON/OFF control.) The HSC parameter determines the switching differential value.

3. **Reset/Integral Adjustment**: Gradually increase **rE**, or decrease **It** until the upper display temperature begins to oscillate or "hunt." Then slowly decrease **rE** or increase **It** until the upper display stabilizes again near set point.

4. **Cycle Time Adjustment**: Set **Ct** as required. Faster cycle times sometimes achieve the best system control. However, if a mechanical contactor or solenoid is switching power to the load, a longer cycle time may be desirable

to minimize wear on the mechanical components. Experiment until the cycle time is consistent with the quality of control you want. Ct will not appear on units with a process output.

5. **Rate/Derivative Adjustment**: Increase **rA/dE** to 1.00 minute. Then raise set point by 20° to 30°F, or 11° to 17°C. Observe the system's approach to set point. If the load temperature overshoots set point, increase **rA/dE** to 2.00 minutes.

   Raise set point by 20 to 30°F, or 11 to 17°C and watch the approach to the new set point. If you increase **rA/dE1** too much, approach to set point is very sluggish. Repeat as necessary until the system rises to the new set point without overshooting or approaching the set point too slowly.

6. **Calibration Offset Adjustment:** You may want your system to control to a temperature other than the value coming from the input sensor. If so, measure the difference between that temperature (perhaps at another point in the system) and the process value showing in the upper display. Then enter the **CAL** offset value you want. Calibration offset adds or subtracts degrees from the value of the input signal.

Manual and Automatic Operation

NOTE:
Process Input does not have sensor break protection or bumpless transfer. Outputs selected as Ht (reverse acting) will be full on if sensor break occurs.

To change from auto to manual operation, press the A/M key twice.

Manual operation provides open loop control of the outputs from a range of -100% (full cooling) to 100% (full heating) power. The 965 allows a negative output value only with a Cl (Cool) selection on either Ot1 or Ot2 = Con. Automatic operation provides closed loop on/off or PID control. When the operator transfers from a closed loop to an open loop, the 965 retains the power level from the closed loop control, referred to as bumpless transfer. When the 965 returns to closed loop control, it restores the previous set point temperature.

The MN LED indicates auto or manual operation. When the LED is on, the control is in manual operation. When the LED is off, it is in automatic operation. When the LED flashes, press the key again within five seconds to complete the change in operation.

When a sensor opens, the 965 switches from automatic to manual operation if LOC = 0, 1 or 2.

- If LOC = 0, 1 or 2 and the bumpless transfer conditions are met, process has stabilized at a ± 5% power level for a 2 minute period prior to sensor break provided the power level is less than 75%. The 965 switches to manual operation at the last automatic power level.

- If LOC = 3 or 4, the 965 switches into manual operation at 0% power (outputs disabled).

When transferring from auto to manual operation, the control output(s) remains stable ("bumpless," smooth transition). When transferring from manual to automatic operation, the control output(s) may change significantly. In manual operation, the output value appears in the lower display; in automatic operation, the set point appears.

NOTE:
When the alarm output is de-energized, the NO contact is open in the alarm condition.

Using Alarms

The Series 965 has two alarm types, Process or Deviation. A **process alarm** sets an absolute temperature. When the process exceeds that absolute temperature limit an alarm occurs. The process alarm set points may be independently set high and low. Under the Setup Menu, select the type of alarm output with the Ot2 parameter. PrA = Process Alarm   Pr = Process alarm with no alarm message displayed

A **Deviation alarm** alerts the operator when the process strays too far from set point. The operator can enter independent high and low alarm settings. The reference for the deviation alarm is the set point. Any change in set point causes a corresponding shift in the deviation alarm. dEA = Deviation Alarm
dE = Deviation alarm with no alarm message displayed

Example: If your set point is 100°F/38°C, and a deviation alarm is set at +7°F/4°C as the high limit, and -5°F/3°C as the low limit, the high alarm trips at 107°F/41.6°C, and the low alarm at 95°F/35°C. If you change the set point to 130°F/54.4°C, the alarms follow the set point and trip at 137°F/59°C and 125°F/51.6°C.

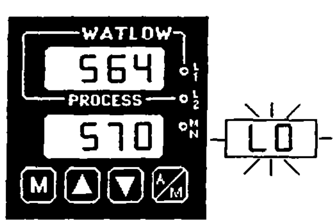
Under the Setup Menu, select the type of alarm output with the Ot2 parameter.
dEA = Deviation Alarm dE = Deviation alarm with no alarm message displayed

Both process and deviation alarms can be latching or non-latching. When the alarm condition is removed a **non-latching alarm automatically** clears the alarm output. You must **manually clear a latching alarm** before it will disappear.

Flashing "LO" or "HI" in the lower display indicates an alarm when Ot2 = PrA or dEA. The lower display alternately shows information from the current parameter and the "LO" or "HI" alarm message at one second intervals. The alarm output is de-energized and the L2 LED is lit.

To clear an alarm...

- **First correct the alarm condition, then...**
  - **If the alarm is latching...**
    Clear it manually; press the A/M key once as soon as the process temperature is inside the HSA parameter alarm limit.
  - **If the alarm is non-latching...**
    The alarm clears itself automatically as soon as the process temperature is inside the HSA parameter alarm limit.



Press once - Clear a latched and corrected alarm.

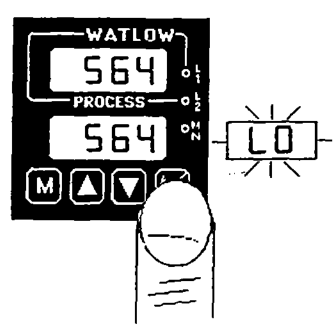
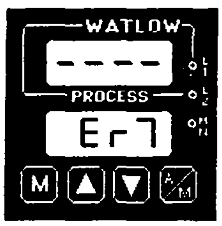


Figure 26 - Alarm Display Examples

Alarm Silencing is available with the deviation alarm. When SIL is selected as "on," the operator must manually disable the alarm by pressing the A/M key once on initial power up (in either the latching or non-latching mode). Alarm silencing disables the alarm output relay. However, the L2 LED (also the lower display when Ot2 = dEA) shows an alarm condition until the process value is within the "safe" region of the deviation alarm band. Once the process value crosses into the "safe" region, both a latching or a non-latching alarm is ready. Any future deviation outside this safe band triggers an alarm.

Error Code Messages ⚠

Four dashes, "- - - -", in the upper display indicate a Series 965 error. The error code is visible in the lower display.



NOTE:
An alarm display will be masked by an error condition or when the control is in the Calibration or Setup Menus.

Er 2 - Sensor underrange error (only applies to RTD units)
The sensor input generated a value lower than the allowable signal range, or the A/D circuitry malfunctioned. Enter a valid input. Make sure the **In** parameter (selected in the Setup menu) and the DIP switch settings both match your sensor. Refer to the table below for the appropriate input type and range.

Er 4 - Configuration error
The unit's microprocessor is faulty; call the factory.

Er 5 - Non volatile checksum error
The nonvolatile memory checksum discovered a checksum error. Unless a momentary power interruption occurred while the unit was storing data, the nonvolatile memory is bad. Call the factory.

Er 6 - A/D underflow error
The A/D circuit is underrange. An open or reversed polarity sensor is the most likely cause. Check the sensor; if the connection is good and functions properly, call the factory. The A/D underrange voltage is too low to convert an A/D signal. Make sure the **In** parameter matches your sensor and DIP switches are set accordingly.

Er 7 - A/D overflow error
The A/D circuit is overrange. An open or reversed polarity sensor is the most likely cause. Check the sensor; if the connection is good, and the sensor functions properly, call the factory. The A/D overrange voltage is too high to convert an A/D signal. Make sure the **In** parameter matches your sensor and DIP switches are set accordingly.

⚠
CAUTION:
Electrical noise or a noise event, vibration or excess environmental moisture or temperature may cause Series 965 errors to occur. If the cause of an error is not otherwise apparent, check for these.

Error Code Actions

• Er 2, Er 6, Er 7 result in these conditions:

- **If operator access is LOC 0, 1 or 2 ...**
  ...and the control was in AUTO operation when the error occurred, it goes into manual (% power) operation. If the output power is less than 75% power, and a <5% change in power occurred within the last two minutes, the 965 switches into manual operation at the last automatic power level (bumpless transfer). If the control was in manual operation, it remains there. Press A/M twice to see the error code. The alarm output (if present) is in its alarm state (LED lit). The upper display reads "- - -". The lower display indicates the error code.

  If the control was operating with stable output values when the error occurred, it continues to operate at those levels on a % power basis. If output values were not stable, the control outputs go to 0% power (OFF).

- **If operator access is LOC 3 or 4...**
  The control remains in auto operation and the outputs go off. The A/M and MODE keys are inactive. The Up-arrow/Down-arrow keys may be used simultaneously to enter the Setup Menu. The alarm output (if present) is in its alarm state (LED lit). The upper display reads "- - - -". The lower display indicates the error code.

- **To clear a corrected error...**
  - Press M (Mode key).

• Er 4 and Er 5 result in these conditons:

- The control is in auto operation with both outputs off.
- The alarm output, if present, are in their alarm state (de-energized with the LED lit).
- The upper display indicates the process value.
- The lower display indicates the error code.
- All keys are inactive.
- All Setup Menu parameters return to default values.
- The above conditions occur regardless of the value of LOC, or the presence of the Setup or Calibration Menus.

- **To clear a corrected error...**
  - Cycle power to the control.

Appendix 1

Noise and Installation Guidelines

For wiring guidelines, refer to the IEEE Standard No. 518-1982, available from IEEE, Inc. 345 East 47th Street, New York, NY 10017.

Noise Sources

- Switches and relay contacts operating inductive loads such as motors, coils, solenoids, and relays, etc.
- Thyristors or other semiconductor devices which are not zero crossover-fired (randomly-fired or phase angle-fired devices).
- All welding machinery and heavy current carrying conductors.
- Fluorescent and neon lights.

Decreasing Noise Sensitivity

- Physical separation and wire routing must be given careful consideration in planning the system layout. For example, ac power supply lines should be bundled together and physically kept separate from input signal lines (sensor lines). A 12" (305 mm) minimum separation is usually effective. Keep all switched output signal lines (high power level) separate from input signal lines (sensor lines). Cross other wiring at 90° angles whenever crossing lines is unavoidable.

- Look at the system layout; identify and locate electrical noise sources such as solenoids, relay contacts, motors, etc. Route the wire bundles and cables as far away as possible from these noise sources. Don't mount relays or switching devices close to a microprocessor control. Don't have phase angle-fired devices in the same electrical enclosure or on the same power line with the control.

- Shielded cables should be used for all low power signal lines to protect from magnetic and electrostatic coupling of noise. Some simple pointers are:

  ◊ Whenever possible, run low level signal lines unbroken from signal source to the control circuit.
  ◊ Connect the shield to the control circuit common at the control end only. Never leave the shield unconnected at both ends. Never connect both shield ends to a common or ground.
  ◊ Maintain shield continuity at daisy chain connection points by reconnecting the broken shield.
  ◊ Assume no electrostatic shielding when using the shield as a signal return. If you must do this, use triaxial cable (electrostatically shielded coaxial cable).

- Use twisted pair wire any time control circuit signals must travel over two feet, or when you bundle them parallel with other wires.
- Select the size or gauge of wire by calculating the maximum circuit current and choosing the gauge meeting that requirement. Using greatly larger wire sizes than required generally increases the likelihood of electrostatic (capacitance) coupling of noise.
- Eliminate ground loops in the entire control system. You can spot the obvious loops by studying the "as-built" wiring diagram. There are also not-so-obvious ground loops resulting from connecting internal circuit commons in the manufacturer's equipment.
- Do not daisy chain ac power (or return) lines, or output signal (or return) lines to multiple control circuits. Use a direct line from the power source to each input requiring ac power. Avoid paralleling L1 (power lead) and L2 (return lead) to load power solenoids, contactors, and control circuits. If an application uses L1 (power lead) to switch a load, L2 (return lead) has the same switched signal and could couple unwanted noise into a control circuit.
- Tie all ground terminals together with one lead (usually green wire) tied to ground at one point. Don't connect ground to the control case if the control is in a grounded enclosure (preventing ground loops).
- Do not confuse chassis grounds (safety ground) with control circuit commons or with ac supply L2 (return or neutral line). Each return system wiring must be separate. Absolutely never use chassis ground (safety) as a conductor to return circuit current.

Eliminating Noise

- Use "snubbers" (QUENCHARC™ P/N: 0804-0147-0000) to filter out noise generated by relays, relay contacts, solenoids, motors, etc. A snubber is a simple filter device using a 0.1µf, 600 volt, non-polarized capacitor in series with a 100Ω, 1/2 watt resistor. The device can be used on ac or dc circuits to effectively dampen noise at its source.
- The ultimate protection is an "uninterruptable" power supply. This "senses" the ac power line; when the line fluctuates, a battery powered 60Hz inverted circuit takes over, supplying power within one-half to one cycle of the ac line; very expensive.

Appendix 2

Calibration

Before attempting to calibrate, make sure you read through the procedures carefully and have the proper equipment called for in each procedure. Make sure the DIP switches are in the proper position per input type. See Page 14.

Entering the Calibration Menu

In the Calibration Menu, various input signals must be supplied for the control to go through its auto calibration. The calibration menu can only be entered from the LOC parameter in the Setup Menu. Press the Up-arrow/Down-arrow keys simultaneously for 3 seconds (± 1 second). The CAL parameter appears in the lower display with "no" in the upper display.

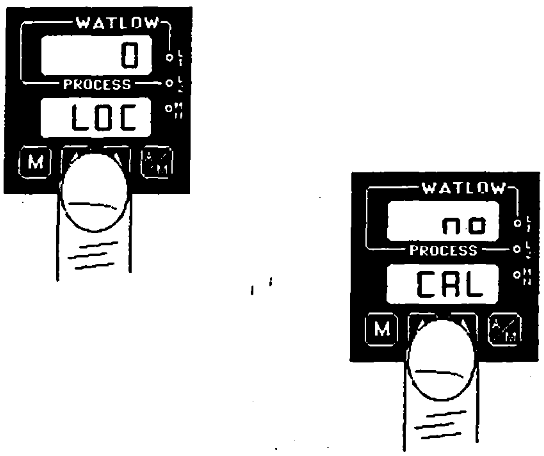


Figure 27 - Entering the Calibration Menu.

NOTE:
Calibration values will not be retained unless you are in the MANUAL mode. Do not enter the MANUAL mode until you are at the correct input parameters.

Any inadvertent change in the displayed data, when pressing the Up-arrow/ Down-arrow keys, is ignored. Calibration values won't be retained unless you are in the manual mode. Press the Up-arrow/Down-arrow key to change the upper display to "YES." Press MODE to enter the calibration sequence.

Upon entering the calibration menu, the upper display window indicates CAL. It continues to indicate CAL (with the exception of calibration of the 4-20mA output) while the operator walks through the entire calibration parameter list. While calibrating the 4-20mA output, the upper display contains a numeric value to be slewed up or down until the output value is correct. The control uses the lower display to prompt the user as to what the input should be.

NOTE:
While in the Calibration Menu, the control output(s) go off and the alarm output (if present) is on.

With the dFL parameter, select either U.S. parameters which include displaying °F, rate, reset, and proportional band in degrees or units. Or select SI (System International) and the displayed parameters are °C, integral, derivative, and proportional band in % of span.

Once the information has been properly established and maintained for at least 5 to 10 seconds, the MODE key may then be used to display the next prompt. After the final input is established, press the MODE key twice to return the unit to the configuration menu at the top of the parameter list.

Restoring Factory Calibration

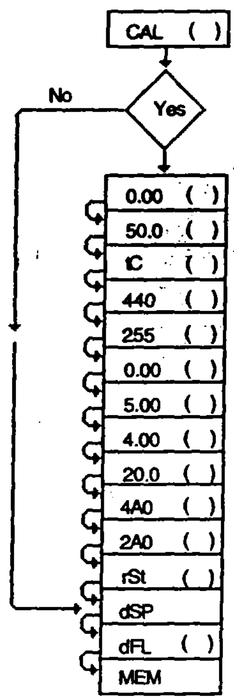
The rSt parameter restores the factory calibration values to the Series 965. If you calibrate your control incorrectly, you have the option to default to the original values. Once you leave the CAL menu, the values are entered.

1. Press the Up-arrow/Down-arrow keys simultaneously for three seconds. The LOC parameter appears in the lower display. Continue holding the Up-arrow/Down-arrow keys until the lower display reads CAL.
2. Press the Up-arrow key until YES appears in the upper display.
3. MODE through the calibration menu until rSt appears in the lower display.
4. Press the Up-arrow key until YES appears in the upper display.
5. Press the MODE key and the 965 advances to test the displays.

This procedure is used only to restore calibration, it is not meant to clear values.

Calibration Menu

Figure 28 - Calibration Parameters



CAL ( )	YES to calibrate, No skips to display test.
0.00 ( )	Input 0.00mV for low input.
50.0 ( )	Input 50.00mV for high input.
tC ( )	Connect a Type "J" ambient compensator with inputs shorted.
440 ( )	Set the low resistance to 44.01Ω.
255 ( )	Set the high resistance to 255.42Ω.
0.00 ( )	Set the voltage source to 0.000 volts.
5.00 ( )	Set the voltage source to 5.000 volts.
4.00 ( )	Set the current source to 4.00mA.
20.0 ( )	Set the current source to 20.00mA.
4A0 ( )	Enter 4-20mA output calibration value for 4mA.
2A0 ( )	Enter 4-20mA output calibration value for 20mA.
rSt ( )	Restores factory calibration values.
dSP	Factory use only.
dFL ( )	Select US (rate, reset, proportional band in degrees or units, °F) or SI (integral, derivative, proportional band in % of span, °C)
MEM	Factory use only.

⚠

Before attempting to calibrate, make sure you have the proper equipment called for in each procedure.

The Series 965 is calibrated and tested before leaving the factory.

Thermocouple Field Calibration Procedure

Equipment Required

- Type "J" Reference Compensator with reference junction at 32°F/0°C, or Type "J" Thermocouple Calibrator set at 32°F/0°C.
- Precision millivolt source, 0-50mV min. range, 0.01mV resolution

Setup And Calibration

1. Connect the AC line voltage L1 and L2 to the proper terminals.
2. Connect the millivolt source to Terminal 5 Negative and Terminal 3 Positive on the Series 965 terminal strip. Use regular 20 - 24 gauge wire. Make sure the DIP switch is set for thermocouple input, see Chapter 4.
3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Figure 27 on Page 29. Select **YEs**.
4. Press the A/M key twice to enter the MANUAL mode. The unit is calibrating when MN LED is on. Make sure the unit is in MANUAL mode only when you are in the correct parameters.
5. At the 0.00 prompt, enter 0.00mV from the millivolt source to the control. Allow at least 10 seconds to stabilize. Press the MODE key.
6. At the 50.0 prompt, enter 50.00mV from the millivolt source to the Series 965. Allow at least 10 seconds to stabilize. Press the MODE key.
7. At the **tC** prompt, disconnect the millivolt source, and connect the reference compensator or T/C calibrator to Terminal 5 Negative, and Terminal 3 Positive on the Series 965 terminal strip. If using a compensator, turn on and short the input wires. If using "J" calibrator, set to simulate 32°F/0°C. Allow 10 seconds for the control to stabilize. The unit will leave the CAL mode if 1 minute passes between key activations. To conclude the T/C calibration, advance the MODE key to the next prompt or exit the CAL menu. Press the A/M key twice to exit the MANUAL mode.

NOTE:
Before calibration on an installed control, make sure all data and parameters are documented. See Setup and Operation Tables, Pages 18 and 20.

NOTE:
When the MN LED is on, the unit is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment.

RTD Field Calibration Procedure

Equipment Required

- 1KΩ precision decade resistance box with 0.01Ω resolution.

Setup And Calibration

1. Connect the ac line voltage L1 and L2 to the proper terminals.
2. Connect the decade resistance box to Terminal 2, 3 and 5 on the terminal strip. Use regular 20 - 24 gauge wire of the same length and type. Make sure the DIP switch is set for RTD input, see Chapter 4.
3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Figure 27 on Page 29. Select **YEs**. Press the MODE key until the **440** prompt is displayed.
4. Press the A/M key twice to enter the MANUAL mode. The unit is calibrating when the MN LED is on. Make sure the unit is in MANUAL mode **only** when you are in the correct parameters.
5. At the **440** prompt, set the decade resistance box to 44.01. Allow at least 10 seconds to stabilize. Press the A/M key twice to exit the MANUAL mode. The unit will leave the CAL mode if 1 minute passes between key activations. To conclude the RTD calibration, advance the MODE key to the next prompt or exit the CAL menu.
6. At the **255** prompt, set the decade resistance box to 255.42. Allow at least 10 seconds to stabilize. Press the MODE key.

0-5 Volt Input Field Calibration Procedure

NOTE:
Before calibration on an installed control, make sure all data and parameters are documented. See Setup and Operation Charts, Pages 18 and 20.

Equipment Required:

- Precision DC voltage source 0-5 volt minimum range with 0.001 volt resolution.

Setup and Calibration

1. Connect the AC line voltage L1 and L2 to the proper terminals on the 965.
2. Connect the voltage/current source to Terminal 3 (+) and 5 (-) on the Series 965 terminal strip. Use regular 20 - 24 gauge wire. Make sure the DIP switch is set for process input, see Chapter 4.
3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Figure 27 on Page 29. Select **YEs**. Press the MODE key until **0.00** is displayed.
4. Press A/M twice to enter the MANUAL mode. The unit is calibrating when the MN LED is on. Make sure the unit is in the MANUAL mode **only** when you are in the correct parameters. See Figure 28.
5. At the **0.00** parameter, set the voltage source to 0.000 volts. Allow at least 10 seconds to stabilize. Press the MODE key.
6. At the **5.00** parameter, set the voltage source to 5.000V⎓ (VDC). Allow at least 10 seconds to stabilize. The unit leaves the CAL mode if 1 minute passes between key activations. Press A/M twice to exit the MANUAL mode. To conclude the 0-5 Volt calibration, advance the MODE key to the next prompt or exit the CAL menu.

4-20mA Input Field Calibration Procedure

NOTE:
When the MN LED is on, the unit is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment.

Equipment Required:

- Precision current source 0-20mA minimum range with 0.01mA resolution.

Setup and Calibration

1. Connect the AC line voltage L1 and L2 to the proper terminals on the 965.
2. Connect the current source to Terminal 2 (-) and 5 (+) on the Series 965 terminal strip. Use regular 20 - 24 gauge wire. Make sure the DIP switch is set for process input, see Chapter 4.
3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Figure 27 on Page 29. Select **YEs**. Press the MODE key until **4** is displayed.
4. Press A/M twice to enter the MANUAL mode. The unit is calibrating when the MN LED is on. Make sure the unit is in the MANUAL mode **only** when you are in the correct parameters. See Figure 28 on Page 30.
5. At the **4.00** parameter, set the current source to 4.00mA. Allow at least 10 seconds to stabilize. Press the MODE key.
6. At the **20.0** parameter, set the current source to 20.00mA. Allow at least 10 seconds to stabilize. The unit leaves the CAL mode if 1 minute passes between key activations. Press A/M twice to exit the MANUAL mode. To conclude, advance the MODE key to the next prompt or exit the CAL menu.

4-20mA Output Field Calibration Procedure

Equipment Required:

- 300Ω, 1/2 watt 10% resistor.
- 4 - 1/2 digit Digital Multimeter.

Setup And Calibration

1. Connect the ac line voltage L1 and L2 to the proper terminals of the 965. See Chapter 2. Set the multimeter to measure current.
2. Connect the multimeter in series with the 300Ω resistor to Terminal 9 Positive and 10 Negative on the Series 965 terminal strip. Use regular 20 - 24 gauge wire.
3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. Press the MODE key until the **4A0** prompt is displayed.
4. Press the A/M key twice to enter the MANUAL mode. The unit is calibrating when the MANUAL LED is on.
5. At the **4A0** prompt, the multimeter should read approximately 4mA. Allow at least 10 seconds to stabilize.
6. Use the Up-arrow/Down-arrow keys (reverse acting) to adjust the reading on the multimeter for 3.85mA ± 0.10mA. Press the MODE key.
7. At the **2A0** prompt, the multimeter should read approximately 20mA. Allow at least 10 seconds to stabilize. The unit will leave the CAL mode if 1 minute passes between key activations except for 4-20mA units.
8. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 20.15mA ±0.10mA.
9. To conclude the 4-20mA output calibration, advance the MODE key to the next prompt or exit the CAL menu.

NOTE:
Before calibration on an installed control, make sure all data and parameters are documented. See Setup and Operation Charts, Pages 18 and 20.

NOTE:
When the MN LED is on, the unit is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment.

Glossary, A-P

This glossary includes general thermal system control terms.

Alarm: A condition, generated by a controller, indicating that the process has exceeded or fallen below the set or limit point.

Alarm Silence: Disables the alarm relay output.

Anti-reset: Control feature that inhibits automatic reset action outside the proportional band.

Automatic prompts: Data entry points where a microprocessor-based control "prompts" or asks the operator/programmer for information input.

Auto-tune: Automatically tunes the Series 965 PID parameters to fit the characteristics of your particular thermal system.

Bumpless transfer: When transferring from auto to manual operation, the control output(s) will not change ("bumpless," smooth transition).

Closed loop: Control system that has a sensing device for process variable feedback.

Cold junction: Point of connection between thermocouple metals and the electronic instrument.

Cold junction compensation: Electronic means to compensate for the effective temperature at the cold junction.

Cycle time: The time necessary to complete a full on-through-off period in a time proportioning control system.

Derivative: Anticipatory action that senses the rate of change of the process, and compensates to minimize overshoot and undershoot. Also "rate."

Deviation alarm: An alarm referenced at a fixed number of degrees, plus or minus, from set point.

Default parameters: The parameters, or programmed instructions, permanently stored in microprocessor software to provide a data base.

DIN: Deutsche Industrial Norms, a widely-recognized German standard for engineering units.

Display capability: In a digital indicating instrument, the entire possible span of a particular parameter or value.

Droop: Difference in temperature between set point and stabilized process temperature.

Duty cycle: Percentage of "load on time" relative to total cycle time.

Hysteresis: In on/off control, the temperature change necessary to change the output from full on to full off.

Hunting: Oscillation or fluctuation of process temperature between set point and process variable.

Input: Process variable information being supplied to the instrument.

Integral: Control action that automatically eliminates offset, or "droop," between set point and actual process temperature. Also "reset."

Isolation: Electrical separation of sensor from high voltage circuitry. Allows for application of grounded or ungrounded sensing element.

JIS: Joint Industrial Standards. Also Japanese Industrial Standards Committee (JISC). Establishes standards on equipment and components.

Offset: Adjustment to actual input temperature and to the temperature values the Series 965 uses for display and control.

On/off control: Control of temperature about a set point by turning the output full on below set point and full off above set point in the heat mode.

Open loop: Control system with no sensory feedback.

Output: Action in response to difference between set point and process variable.

Overshoot: Condition where temperature exceeds set point due to initial power up or process changes.

P control: Proportioning control.

Parameter: A physical property whose value determines the response of an electronic control to given inputs.

PD control: Proportioning control with rate action.

PI control: Proportioning control with auto-reset.

PID control: Proportioning control with auto-reset and rate.

Process variable: Thermal system element to be regulated, such as time, temperature, relative humidity, etc.

Programmed display data: Displayed information which gives the operator/programmer the "programmed" or intended process information, i.e., intended set point, intended alarm limit, etc.

Proportional band: Span of temperature about the set point where time proportional control action takes place.

Proportioning control: See Time Proportioning Control.

Rate: Anticipatory action that senses the rate of change of temperature and compensates to minimize overshoot. Also "derivative."

Rate band: A thermal control band that defines where the rate (derivative) function begins. A Watlow rate band occurs centered on set point at one or more times the width of the proportional band.

Reference junction: Synonymous with cold junction. See "Cold junction."

Reset: Control action that automatically eliminates offset, or "droop," between set point and actual process temperature. Also "integral."

Reset windup inhibit: Synonymous with anti-reset. See "Anti-reset."

RTD: Resistance Temperature Detector. Resistive sensing device displaying resistance versus temperature characteristics. Displays positive temperature coefficient.

Set point: Intended value of the process variable.

Switching sensitivity: In on/off control, the temperature change necessary to change the output from full on to full off.

Thermal system: A regulated environment consisting of a heat source, heat transfer medium, sensing device and a process variable control instrument.

Thermocouple: Temperature sensing device that is constructed of two dissimilar metals wherein a measurable, predictable voltage is generated corresponding to temperature.

Thermocouple break protection: Fail-safe operation that assures output shutdown upon an open thermocouple condition.

Three mode control: Proportioning control with reset and rate.

Time proportioning control: Action which varies the amount of on and off time when "close" to the set point, i.e., in the proportional band. This variance is proportional to the difference between the set point and the actual process temperature. In other words, the amount of time the output relay is energized depends on the system temperature.

Triac: Solid state switching device.

Upper display data: Displayed information which gives the operator/programmer real or "actual" data, i.e., actual process temperature. See "Programmed display data."

Warm start: Start-up condition where all program information is remembered by the instrument's memory back-up protection.

Zero switching: Action that provides output switching only at the zero-voltage, crossing points of the ac line.

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Warranty

The Watlow Series 965 is warranted to be free of defects in material and workmanship for 36 months after delivery to the first purchaser for use, providing that the units have not been misapplied. Since Watlow has no control over their use, and sometimes misuse, we cannot guarantee against failure. Watlow's obligations hereunder, at Watlow's option, are limited to replacement, repair or refund of purchase price, and parts which upon examination prove to be defective within the warranty period specified. This warranty does not apply to damage resulting from transportation, alteration, misuse, or abuse.

Returns

1. Call Watlow Customer Service, (507)454-5300, for a Return Material Authorization (RMA) number before returning any item for repair. We need this information:
   - Ship to address
   - Bill to address
   - Contact name
   - Phone number
   - Ship via
   - Your P.O. number
   - Symptoms and/or special instructions
   - Name and phone number of person returning the material.

2. Prior approval and an RMA number, from the Customer Service Department, is needed when returning any unused product for credit. Make sure the RMA number is on the outside of the carton, and on all paperwork returned. Ship on a Freight Prepaid basis.

3. After we receive your return, we will examine it and determine the cause for your action.

4. In cases of manufacturing defect, we will enter a repair order, replacement order, or issue credit for material. A 20 percent restocking charge is applied for all returned stock controls and accessories.

5. If the unit is unrepairable, it will be returned to you with a letter of explanation. Repair costs will not exceed 50 percent of the original cost.

Watlow Controls

Watlow Controls is a division of Watlow Electric Mfg. Co., St. Louis, MO, a manufacturer of industrial electric heating products, since 1922. Watlow begins with a full set of specifications and completes an industrial product that is manufactured totally in-house, in the U.S.A. Watlow products include electric heaters, sensors, controls and switching devices. The Winona operation has been designing solid state electronic control devices since 1962, and has earned the reputation as an excellent supplier to original equipment manufacturers. These OEMs depend upon Watlow Controls to provide compatibly engineered controls which they can incorporate into their products with confidence. Watlow Controls resides in a 100,000 square foot marketing, engineering and manufacturing facility in Winona, Minnesota.

Specifications

Specifications—W965-XSPN Rev A01

Control Mode
- Microprocessor-based, user selectable control modes
- Single input, dual output
- Ramp to set point: 0 to 9999 degrees or units per hour
- Heat and cool auto-tune

Agency Approvals
- UL and C-UL recognized, File #E43684, UL873
- CE approved
  89/336/EEC Electromagnetic Compatibility Directive
  EN 50081-2: 1994 Emissions
  EN 50082-2: 1995 Immunity
  73/23/EEC Low -Voltage Directive
  EN 61010-1: 1993 Safety
- NEMA $4X_2$, I.P. 65 rating

Operator Interface
- Sealed membrane front panel
- Dual, four-digit red or green displays
- MODE, Up-arrow, Down-arrow, and AUTO/ MANUAL keys
- User selectable screen display

Accuracy
- Calibration accuracy and sensor conformity: ±0.1% of span, ±1 LSD @ 77°F ± 5°F (25°C ± 3°C) ambient and rated line voltage
- Accuracy span: 1000°F (540°C) minimum
- Temperature stability: ±0.2°F/°F (±0.2°C/°C) rise in ambient maximum
- Voltage stability: ±0.01% of span per percent of rated line voltage

Sensors/Inputs
- Thermocouple, grounded or ungrounded sensors
- RTD 2- or 3-wire, platinum, 100Ω @ 0°C calibration to DIN curve (0.00385Ω/Ω/°C) or JIS curve (0.003916Ω/Ω/°C); user selectable
- Process, 4-20mA @ 5Ω, or 0-5V= (dc) @ 10kΩ input impedance
- Sensor break protection de-energizes control output to protect system or selectable bumpless transfer to manual operation
- °F or °C or process units display, user selectable

Input Range
Specified temperature ranges represent the controller's operational span.
- **Thermocouple**

Type J	32	to	1382°F
	(0	to	750°C)
Type K	-328	to	2282°F
	(-200	to	1250°C)
Type N	32	to	2282°F
	(0	to	1250°C)
Type S	32	to	2642°F
	(0	to	1450°C)
Type T	-328	to	662°F
	(-200	to	350°C)

- **RTD Resolution (DIN or JIS)**

1°	-328	to	1292°F
	(-200	to	700°C)
0.1°	-199.9	to	999.9°F
	(-128.8	to	537.7°C)

- **Process**
  4-20mA @ 5Ω, or -999 to 9999 units
  0-5V= (dc) @ 10kΩ, or -999 to 9999 units

Output 1 (Heating or Cooling)
- Electromechanical $relay_1$, Form C, 5A @ 120/240V~ (ac) maximum, without contact suppression, rated resistive load, 5A @ 30V= $(dc)_3$.
- Switched dc signal provides a non-isolated minimum turn on voltage of 3V= (dc) into a minimum 500Ω load; maximum on voltage not greater than 12V= (dc) into an infinite load.
- 4-20mA reverse or direct acting, non-isolated 0 to 800Ω load.
- Solid-state $relay_3$, Form A, 0.5A @ 24V~ (ac) min., 264V~ (ac) max., opto-isolated burst fire switched, without contact suppression. Off-state output impedance is 31MΩ.

Output 2 (Heat, Cool or Alarm)
- Electromechanical $relay_1$, Form C, 5A @ 120/240V~ (ac) maximum, without contact suppression, rated resistive load, 5A @ 30V= $(dc)_3$.
- Switched dc signal provides a non-isolated minimum turn on voltage of 3V= (dc) into a minimum 500Ω load; maximum on voltage not greater than 12V= (dc) into an infinite load.
- Solid-state $relay_3$, Form A, 0.5A @ 24V~ (ac) min., 264V~ (ac) max., opto-isolated burst fire switched, without contact suppression. Off-state output impedance is 31MΩ.
- Alarm output can be latching or non-latching, and process or deviation with separate high and low values. Alarm silencing (inhibit) on power up.

Output Configurations
- **Output 1**

User selectable as: on/off: P, PI, PD, PID, heat or cool action
- Adjustable switching differential: 1 to 99°F (1 to 55°C)
- Proportional band: 0 (off) or 1 to 999°F (0 to 555°C) or 0.0 to 999.9 units

Integral: 0 (off) or 0.1 to 99.9 minutes per repeat
Reset: 0 (off) or 0.01 to 9.99 repeats per minute
Rate/derivative: 0 (off) or 0.01 to 9.99 minutes
Cycle time: 0.1 to 999.9 seconds
- **Output 2**

User selectable as: Control with action opposite that of Output 1 (heating or cooling)
- Process or deviation alarm with flashing alarm message
- Process or deviation alarm without alarm message
- Alarm with separate high and low set points
- Hysteresis: 1 to 9999° or units switching differential

Line Voltage/Power
- 100-240V~ (ac), +10%, -15%; (85-264V~ [ac]) 50/60Hz, ±5%
- 12-24V≂ (ac/dc), +10%, -15%; (10-26V≂ [ac/dc]) 50/60Hz, ±5%
- Fused internally (factory replaceable only) Slo-Blo® type (time-lag):
  1A, 250V for high voltage versions
  2A, 250V for low voltage versions
- Power consumption 5VA maximum
- Data retention upon power failure via non-volatile memory

Operating Environment
- 32 to 149°F (0 to 65°C)
- 0 to 90% RH, non-condensing

Storage Temperature
- -40° to 185°F (-40° to 85°C)

Terminals
- #6 compression universal head screw terminals, accepts 20-14 gauge wire

Controller Weight
- 0.4 lb (0.2 kg)

Shipping Weight
- 0.75 lb (0.34 kg)

Dimensions
- Compact 1/16 DIN size and NEMA $4X_2$, (I.P. 65) front panel make the Series 965 easy to apply and maintain in a wide variety of applications. Unique mounting bezel, gasket and collar make installation a snap.

Overall	Height:	2.1 inches	(55 mm)
	Width:	2.1 inches	(55 mm)
	Depth:	4.7 inches	(120 mm)
Bezel	Height:	2.1 inches	(55 mm)
	Width:	2.1 inches	(55 mm)
	Depth:	0.6 inches	(15 mm)
Chassis	Height:	1.8 inches	(45 mm)
	Width:	1.8 inches	(45 mm)
	Depth:	4.1 inches	(105 mm)

[1] Electromechanical relays warranted for 100,000 closures only. Solid-state switching devices recommended for applications requiring fast cycle times or extended service life.
[2] To effect NEMA 4X (I.P. 65) rating requires a minimum mounting panel thickness of 0.06inch (1.5 mm) and surface finish not rougher than 0.000032 inch (0.000812 mm).
[3] Switching inductive loads (relay coils, etc.) requires using an RC suppressor.

Series 965 Model Number Information

Ordering Information—W965-XMNN Rev A00

965A-3 _ _ _ -00 _ _

Output 1
C = Switched dc output, non-isolated
D = Electromechanical relay, Form C, 5A, without contact suppression[1,3]
F = Process, 4-20mA⎓ (dc), non-isolated
K = Solid-state relay, Form A, 0.5A, without contact suppression[3]

Output 2
A = None
C = Switched dc output, non-isolated
D = Electromechanical relay, Form C, 5A, without contact suppression[1,3]
K = Solid-state relay, Form A, 0.5A, without contact suppression[3]

Line Voltage/Power
0 = 100-240V~ (ac) nominal (high voltage)
1 = 12-24V~ (ac) nominal or 12-24V⎓ (dc) (low voltage)

Display

	Upper Display	Lower Display
00 =	Red	Red
RG =	Red	Green
GR =	Green	Red
GG =	Green	Green

* Note: If this output will drive a solenoid, MDR, contactor or other inductive device, order a Quencharc™ (0804-0147-0000) for output protection. See Chapter 2 for wiring.

Spare Parts

• Mounting collar	0822-0395-0000
• Case gasket	0830-0402-0002
• Protective terminal cover	0822-0426-0001
• Internal bezel gasket	0830-0402-0001
• Quencharc™ RC suppressor	0804-0147-0000

Declaration of Conformity

WATLOW CONTROLS
1241 Bundy Boulevard
Winona, Minnesota 55987
USA

Declares that the following product:

Designation:	Series 965
Model Number(s):	9 6 5 A - 3 (C D F or K) (A C D or K) (0 or 1) - (Any four numbers or letters)
Classification:	Control, Installation Category II, Pollution Degree II
Rated Voltage:	100 to 240V~ (VAC) or 12 to 24V≂ (VAC/VDC)
Rated Frequency:	50/60 Hz
Rated Power Consumption:	5VA maximum

Meets the essential requirements of the following European Union Directive(s) using the relevant section(s) of the normalized standards and related documents shown:

89/336/EEC Electromagnetic Compatibility Directive

EN 50082-2: 1995 EMC Generic immunity standard, Part 2: Industrial environment

EN 61000-4-2:	1995	Electrostatic discharge
EN 61000-4-4:	1995	Electrical fast transients
ENV 50140:	1994	Radiated immunity
ENV 50141:	1994	Conducted immunity
ENV 50204:	1995	Cellular phone

EN 50081-2: 1994 EMC Generic emission standard, Part 2: Industrial environment

EN 55011:	1991	Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical radio-frequency equipment (Class A)

73/23/EEC Low-Voltage Directive

EN 61010-1: 1993 Safety requirements for electrical equipment for measurement, control, and laboratory use, Part 1: General requirements

Winona, Minnesota, USA
Place of Issue

May 15, 1996
Date of Issue

Erwin D. Lowell
Name of Authorized Representative

General Manager
Title of Authorized Representative

Signature of Authorized Representative

W965-XCEN-0000 Rev A01

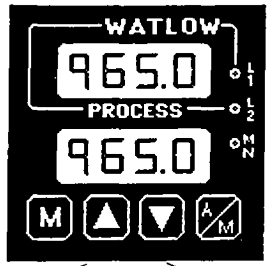
Series 965 Quick Reference

Use this page as a quick reference for the Series 965. Tear along the perforation.

Keys & Displays

Upper Display: Red or green, LED display, indicating either process actual temperature, the operating parameter values, or an open sensor.

Lower Display: Red or green, four digit LED display, indicating the set point, output value, parameters for data in the upper display, or error and alarm codes.



L1: When lit it indicates Output 1 is energized.

L2: When lit it indicates when Output 2 is active. This output can be configured as a control or alarm output.

MN: Lit when in manual operation. Press A/M twice to enter Automatic. When blinking, press A/M to toggle between Auto and Manual. After 5 seconds without key activations it returns to its previous state.

MODE Key: Steps the control through the operating menu, also, in the Auto mode, new data is self entering in 5 seconds.

Up-arrow Key: Increases the value of the displayed parameter. New data is self entering in 5 seconds.

Down-arrow Key: Decreases the value of the displayed parameter. New data is self entering in 5 seconds.

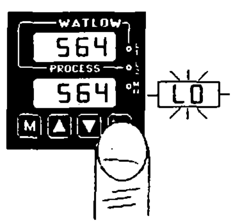
Up-arrow/Down-arrow Keys: When pressed simultaneously for 3 seconds, the Setup Menu appears displaying the LOC parameter. Continue to press the UP/DOWN keys, and the Calibration menu appears.

A/M Key: Press once to clear latched alarms and toggles between Auto and Manual. If pressed within 5 seconds it changes from Auto to Manual or vice versa. While in Manual, percent power is in the lower display.

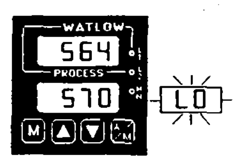
Alarms

Process Alarm sets an absolute temperature. When the process exceeds that absolute temperature limit an alarm occurs. The process alarm set points may be independently set high and low. Under the Setup menu, select the type of alarm output with the Ot2 parameter.
PrA = Process alarm
Pr = Process alarm with no alarm message displayed

Deviation Alarm: Alerts the operator when the process strays too far from set point. The operator can enter independent high and low alarm settings. The reference for a deviation alarm is set point. Any change in set point causes a corresponding shift in the deviation alarm. Under the Setup menu, select the type of alarm output with the Ot2 parameter.
dEA = Deviation alarm
dE = Deviation alarm with no alarm message displayed



Press once to clear a latched and corrected alarm.



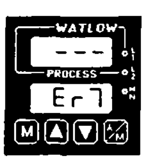
Flashing LO or HI in the lower display indicates an alarm when Ot2 = PrA or dEA. The lower display alternately shows information from the current parameter and a LO or HI alarm message at one second intervals. The alarm output is de-energized, L2 is lit.

Alarm Silencing is available with the deviation alarm. When SIL is selected as "on," the operator must manually disable the alarm by pressing the A/M key once on initial power up (in either the latching or non-latching mode). Alarm silencing disables the alarm output relay. However, the L2 LED (also the lower display when Ot2 = dEA) shows an alarm condition until the process value is within the "safe" region of the deviation alarm band. Once the process value crosses into the "safe" region, both a latching or a non-latching alarm is ready. Any future deviation outside this safe band triggers an alarm.
Both alarms can be latching or non-latching. When the alarm condition is removed a non-latching alarm automatically clears the alarm output. You must manually clear a latching alarm before it will disappear.

To clear an alarm...
- First correct the alarm condition, then...
  - **If the alarm is latching...**
    Clear it manually; press the A/M key once as soon as the process temperature is inside the HSA parameter alarm limit.
  - **If the alarm is non-latching...**
    The alarm clears itself automatically as soon as the process temperature is inside the HSA parameter alarm limit.

Error Codes

Four dashes, "- - - -" or a negative number, in the upper display indicate a Series 965 error. The error code is visible in the lower display.



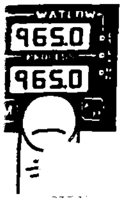
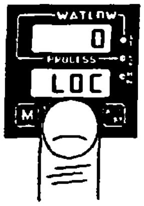
Er 2 - Sensor underrange error (For RTD units only)
The sensor input generated a value lower than the allowable signal range, or the A/D circuitry malfunctioned. Enter a valid input. Make sure the **In** parameter matches your sensor and DIP switch setting. Refer to the table below for the appropriate input type and range.

Er 4 - Configuration error
The unit's microprocessor is faulty; call the factory.

Er 5 - Non volatile checksum error
The nonvolatile memory checksum discovered a checksum error. Unless a momentary power interruption occurred while the unit was storing data, the nonvolatile memory is bad. Call the factory.

Er 6 - A/D underflow error
The A/D circuit is underrange. An open or reversed polarity sensor is the most likely cause. Check the sensor; if the connection is good and functions properly, call the factory. The A/D underrange voltage is too low to convert an A/D signal. Make sure the **In** parameter matches your sensor and the DIP switches are set accordingly.

Er 7 - A/D overflow error
The A/D circuit is overrange. An open or reversed polarity sensor is the most likely cause. Check the sensor; if the connection is good and the sensor functions properly, call the factory. The A/D overrange voltage is too high to convert an A/D signal. Make sure the **In** parameter matches your sensor and the DIP switches are set accordingly.

Entering the Setup Menu

The Setup Menu displays the parameters that configure the Series 965's features to your applicaton.

Enter the Setup menu by pressing the Up-arrow/Down-arrow keys simultaneously for 3 seconds. The lower display shows the LOC parameter, and the upper display shows its current level. All keys are inactive until you release both keys. You can reach the LOC parameter from anywhere.

You will not see all parameters in these menus depending on your unit's configuration and model number.

Setup Menu

LOC ( ) User lock out
In ( ) Input type
dEC ( ) Decimal place
C_F ( ) Celcius__Fahrenheit
rL ( ) Range low
rH ( ) Range high
Ot1 ( ) Output 1
HSC ( ) Control hysteresis
Ot2 ( ) Output 2
HSA ( ) Output 2 hysteresis
LAt ( ) Latching for alarm
SIL ( ) Silence alarm
rtd ( ) RTD calibration curve
rP ( ) Ramp func tion
rt ( ) Ramp rate
PL Power limiting
dSP Display
75

Do not enter any values here; make photocopies instead.

Parameters	Value	Range	Factory Default	Appears If:
LOC		0 through 4	0	
In		J, K (appears as H), t, n, S, rtd, rt.d, 0-5, 420	J	DIP switch selectable
dEC		0, 0.0, 0.00	0	In = 0-5 or 420
C_F		C or F	C F	dFL = SI or In = T/C or RTD dFL = US or In = T/C or RTD
rL		rL to rH	Input dependent	
rH		rH to rL	Input dependent	
Ot1		ht or CL	ht	
HSC		1 to 99, 0.1 - 9.9, 0.01 - 0.99	3, 0.3, 0.03°F	
Ot2		Con = Control PrA = Process alarm Pr = Process with no alarm message dEA = Deviation alarm dE = Deviation with no alarm message no = None	Con	
HSA		1 to 9999, 0.1 - 999.9, 0.01 - 99.99	3, 0.3, 0.03°F	Ot2 ≠ Con or no
LAt		LAt or nLA	nLA	Ot2 ≠ Con or no
SIL		On or OFF	OFF	Ot2 = dEA or dE
rtd		JIS or din	din	In = rtd or rt.d
r P		Str = Ramping on power up on = Ramping to set point at all times OFF = None	OFF	
rt		0 to 9999	100°/hr	rP ≠ OFF
P L		0 to 100	100	
dSP		nor = Normal SEt = Set Point (lower display only) Pro = Process (upper display only)	nor	

Operation Menu

75 Control Set Point
Pb1 ( ) Proportional band 1
rE1/It1 ( ) Reset 1/Integral 1
rA1/dE1 ( ) Rate 1/Derivative 1
Ct1 ( ) Cycle time 1
Pb2 ( ) Proportional band 2
rE2/It2 ( ) Reset 2/Integral 2
rA2/dE2 ( ) Rate 2/Derivative 2
Ct2 ( ) Cycle time 2
ALO Alarm low
AHI Alarm high
CAL ( ) Calibration offset
AUt ( ) Auto-tune

Do not enter any values here; make photocopies instead.

Parameters	Value	Range	Factory Default	Appears If:
Pb1		0 to 999°F/0 to 555°C/0 to 999 Units 0 to 99.9°F/ 0 to 55.5°C/0 TO 99.9 UNITS 0.0 to 999.9% of span 0 = ON/OFF control, HSC = Switching diff.	25°F 2.5°F 3% / .3%	dFL = US dFL = SI
rE1		0.00 to 9.99 repeats/minute / 0.00 = No reset	0.00 repeats/minute	Pb1 ≠ 0 or dFL = US
It1		00.0 to 99.9 minutes/repeat / 0.00 = No integral	00.0 minutes/repeat	Pb1 ≠ 0 or dFL = SI
rA1		0.00 to 9.99 minutes / 0.00 = No rate	0.00 minutes	Pb1 ≠ 0 or dFL = US
dE1		0.00 to 9.99 minutes / 0.00 = No derivativew	0.00 minutes	Pb1 ≠ 0 or dFL is SI
Ct1		0.1 to 999.9 seconds	5.0 seconds	Pb1 ≠ 0 or Output 1 ≠ 420
Pb2		1 to 999°F/0 to 555°C/0 to 999 Units 1 to 99.9°F/ 0 to 55.5°C/0 to 99.9 Units 0.1 to 999.9% of span	25°F 2.5°F 3% / .3%	dFL = US dFL = SI, Ot2 = Con, Pb1 ≠ 0
rE2		0.00 to 9.99 repeats/minute / 0.00 = No reset	0.00 repeats/minute	dFL = US, Ot2 = Con, Pb1 ≠ 0
It2		00.0 to 99.9 minutes/repeat / 0.00 = No integral	00.0 minutes/repeat	dFL = SI, Ot2 = Con, Pb1 ≠ 0
rA2		0.00 to 9.99 minutes / 0.00 = No rate	0.00 minutes	dFL = US, Ot2 = Con, Pb1 ≠ 0
dE2		0.00 to 9.99 minutes / 0.00 = No derivative	0.00 minutes	dFL = SI, Ot2 = Con, Pb1 ≠ 0
Ct2		0.1 to 999.9 seconds	5.0 seconds	Ot2 = Con, Pb1 ≠ 0
ALO		-999° to 0 rL to AHI	-999° rL	Ot2 = dE or dEA Ot2 = Pr or PrA
AHI		0 to 999° ALO to rH	999° rH	Ot2 = dE or dEA Ot2 = Pr or PrA
CAL		± 18°F/±10°C/±18 Units	0	
AUt		0 = off, 1 = slow, 2 = medium, 3 = fast	0	

Eclipse Combustion, Inc.
Information Guide

DR4200 GP Model
Circular Chart Recorder

44-01-25-12

ECLIPSE COMBUSTION, INC.

1665 Elmwood Road • Rockford, IL • Phone: 815-877-3031 • Fax: 815-877-6318

About This Publication

How this manual is organized

This Product Manual is divided into ten sections. These sections contain all the information you need to set up, configure, operate, monitor, and troubleshoot your recorder.

To find information quickly, use the comprehensive Table of Contents in the front of the manual and the Index located in the back of the manual.

Warranty

The device described herein has been manufactured and tested for correct operation and is warranted as follows:

The DR4200 Model GP Circular Chart Recorder carries a two year warranty.

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Acronyms

EMI .... electromagnetic interference
GP .... General Purpose
HID .... high intensity discharge
MOV .... Metal Oxide Varistor
PCB .... Printed Circuit Board
RC .... resistance-capacitance
RFI .... radio frequency interference
RH .... Relative Humidity
SCR .... Silicon controlled rectifier

Section 1 – Overview

1.1 Introduction

Function

The DR4200 General Purpose (GP) Recorder is a one or two pen microprocessor-based circular chart recorder that generates dependable pen drawn analog traces on preprinted 10-inch (250 mm) charts.

User configuration allows setting and/or altering operating parameters to fit your application requirements. You configure the recorder by positioning jumpers and DIP switches on a printed circuit board. The configuration parameters include type of input, chart speed, chart range, alarm settings, control settings, and others.

Both one-pen and two-pen models accept inputs from any one of a variety of sensors and transmitters within the configurable range limits.

Also, models are available with one or two relay outputs for one or both pens to provide alarm, on-off control, and limit control output signals to sound alarms, operate valves, and shutdown processes.

Microprocessor controlled recording

Both the chart and the pen are driven by stepper motors controlled by the microprocessor. Since chart speed is configurable, you can easily alter the chart speed through the DIP switch settings.

The microprocessor uses the configured chart range data as well as the input data to determine proper pen position. The stepper motor accurately positions the pen drive.

Input processing

The input can be one of any standard low-level electrical signals. The input type and range are configurable and can be expanded and compressed within their limits to meet specific measurement needs.

You can select upscale or downscale sensor break protection for most actuations. Analog and digital filters with fixed time constants provide input signal smoothing.

Construction

All DR4200 recorders are housed in a molded case which can be panel or surface mounted. A glass-windowed, gasketed door protects internal components from harsh environments while allowing easy access to the chart.

1.2 Model Number and Hardware Description

Introduction

The DR4200 circular chart recorder is available in one-pen and two-pen models, with or without relays for on-off control and/or alarm outputs.

Since this manual covers all models, we recommend that you decode your recorder's model number first as described below so you can easily identify pertinent instructions in this manual.

Decoding the recorder's model number

Copy the model number that appears on the label on the front of the recorder's chart plate into the boxes shown in Figure 1-1. Use the model number "Table" code definitions to decode your recorder's given hardware characteristics.

Figure 1-1 Model Number Interpretation

DR4200 GP □ □□ □□□□ 0 0 0

Number of Pens	
Code	*Definition*
1	1 Pen
2	2 Pens

Table I - Control Output	
Pen One	
Code	*Definition*
0 –	None
1 –	1 Alarm Relay
2 –	2 Alarm Relays
F –	1 FM approved limit control
Pen Two	
– 0	None
– 1	1 Alarm Relay
– 2	2 Alarm Relays
– F	1 FM approved limit control

Table II - Options	
Code	*Definition*
G – – – – – –	Gray door
B – – – – – –	Blue door
J – – – – – –	Heavy duty gray door
H – – – – – –	Heavy duty blue door
– G – – – – –	Glass window
– P – – – – –	Acrylic window
– – O – – – –	Standard latch (N/A with heavy duty door)
– – K – – – –	Door lock (Standard on heavy duty door)
– – T – – – –	Heavy duty latch
– – – O – – –	No approvals
– – – U – – –	UL listing
– – – C – – –	CSA certification
– – – B – – –	UL and CSA
– – – – O – –	No selection
– – – – – O O	No selection

22036

ATTENTION Every DR4200 Recorder has all the available input actuations stored in its nonvolatile memory. Therefore, you must select the input actuation in the field by setting DIP Switches, selecting jumper positions, and making input wiring connections, as applicable.

Component location

Refer to the views in Figure 1-2 (DR4200GP1) and Figure 1-3 (DR4200GP2) to match given hardware characteristics (Table selections) with the location of actual hardware components in your recorder. This will help you determine applicable input/output wiring needs as well as identify appropriate setup tasks to prepare the recorder for operation later.

To view actual components inside your recorder:

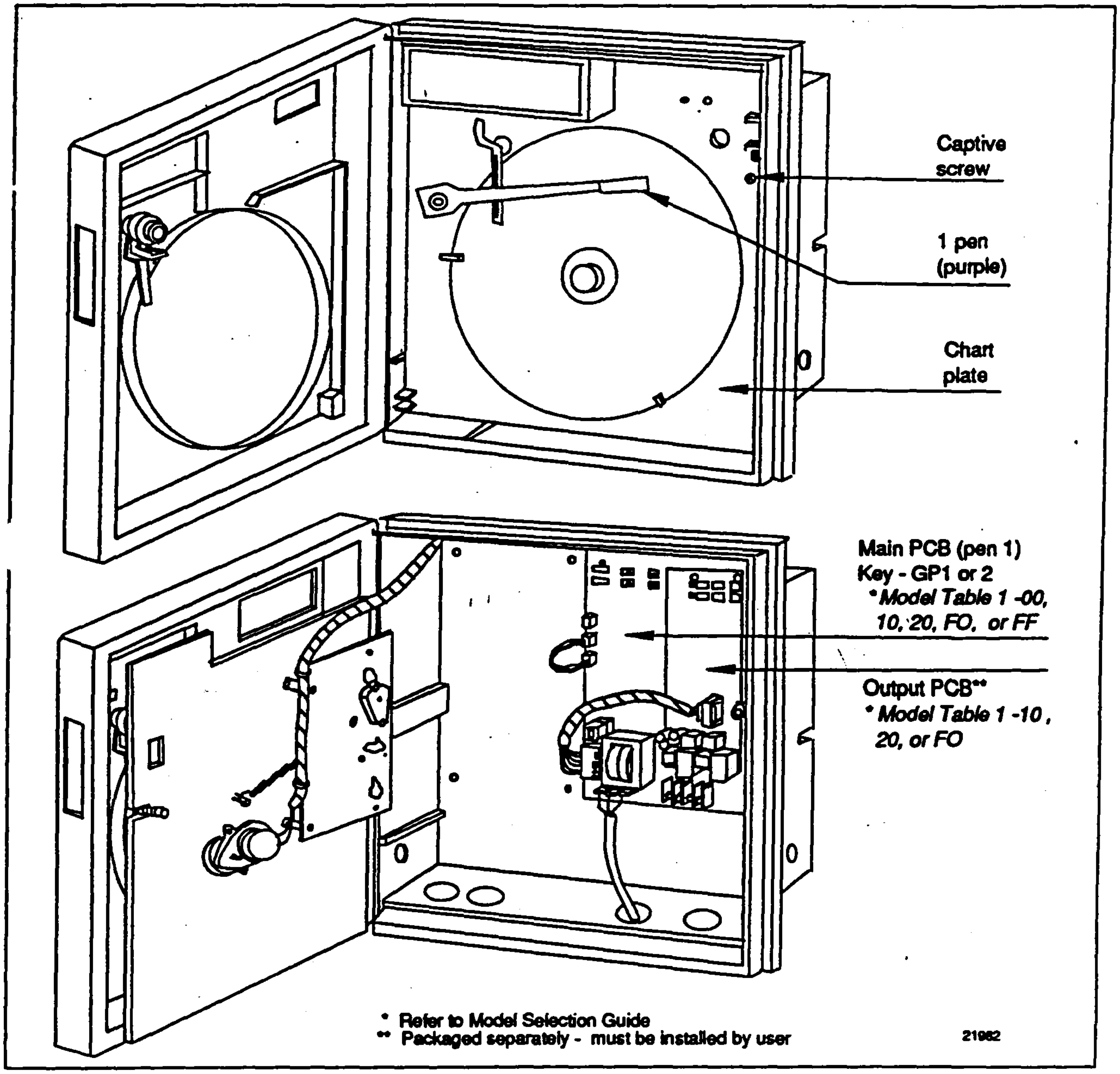
- Push in the button on the recorder door and swing the door open.
- Loosen the captive screw on the right-hand side of the chart plate and swing the chart plate out.

Continued on next page

Model DR4200GP1

Figure 1-2 is a view of the hardware components versus "Table" selections for Model DR4200GP1.

Figure 1-2 Hardware Components for Model DR4200GP1

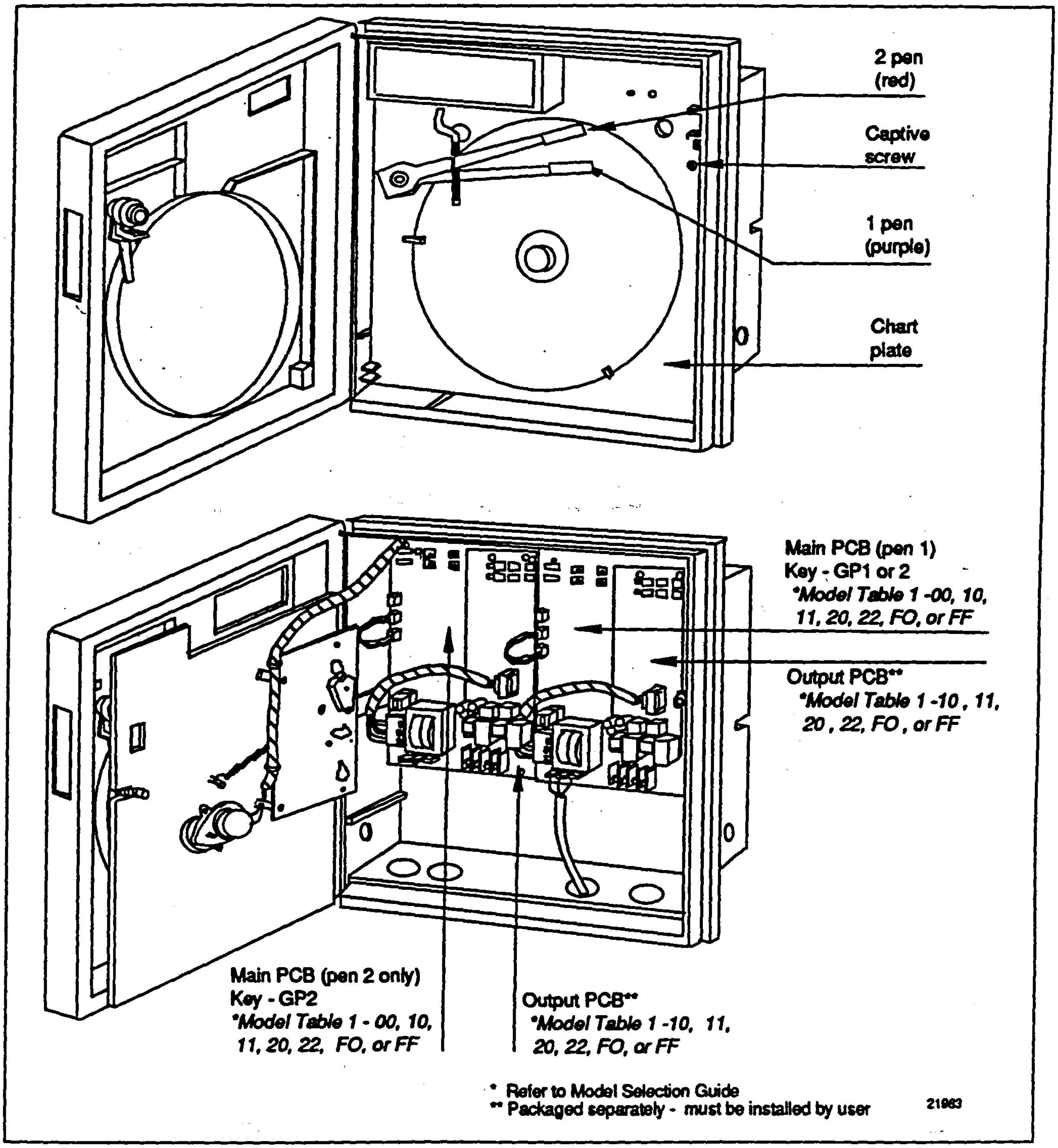


Continued on next page

Model DR4200GP2

Figure 1-3 is a view of the hardware components versus "Table" selections for Model DR4200GP2.

Figure 1-3 Hardware Components for Model DR4200GP2



1.3 Pre-Setup Operational Check

Summary

The DR4200 GP recorder includes a self-test feature that checks the operational status of major recorder functions. You can run the self-test before you setup the recorder for your application requirements. This test will verify that the recorder is operating properly as received from the factory.

For the procedure to run the self-test, refer to subsection 5.3- *Running the Optional Self-Test*.

Section 2 – Recording Set Up

2.1 Introduction

Overview

Recording Set Up consists of checking or setting jumper positions and DIP switch and rotary switch selections for Pen #1 and Pen #2 on each main printed circuit board.

This section contains the set-up tasks required to prepare your recorder for operation. Each separate task includes a general overview of that task and a procedure for you to follow to accomplish it. Unless noted, the procedural steps apply for both Pen #1 and Pen #2 main printed circuit boards.

To help you, there is a composite view of the component locations as well as the factory settings for the jumpers and DIP switches.

Appendix A is a summary of DIP switch and jumper selections on the main printed circuit boards.

If your recorder is supplied with Relay Output (optional), you must also mount the output printed circuit board onto the main printed circuit board and check the DIP switch and jumper locations on that board. Refer to *Section 3 - Optional Relay Output Set Up* for further information.

ATTENTION You can run the pre-operational check given in subsection 5.3 - *Running the Optional Self-Test* before you set-up the recorder and, if desired, you can mount the recorder as outlined in *Section 4 - Installation.*

What's in this section?

The following topics are covered in this section:

2.2 Configuration Selections for Recording

Introduction

There are nine configuration selections that you must make or check to get the recorder to operate in accordance with your application needs:

- Line Voltage
- Run or Set-up Mode
- Burnout
- Chart Linearity
- Zero-and Full-Scale Values
- Temperature Units
- Input Actuation
- Chart Speed
- Main Printed Circuit Board Pen Configuration

How to make selections

This section provides a graphic summary of these configuration settings, and to assist you in the process of selection, it includes configuration worksheets on which you can note the configuration settings you require.

Review the Sample Chart (Figure 2-1) and Sample Worksheet (Figure 2-2). Use the configuration graphics to understand how the sample worksheet was constructed.

Get a copy of the chart that you will be using on your DR4200 recorder and, using Figure 2-1 as a guide, note the configuration selections you must make for your particular recording needs.

View the pertinent configuration selection illustrations for recording and mark the required settings on the Configuration Worksheet provided in the back of this section. If you have a two-pen recorder, mark the worksheet provided for Pen #2.

Make the actual configuration settings on the Main printed circuit board in the recorder to match the worksheet.

The recorder is now ready for operation.

WARNING To avoid personal injury never access components inside the case with power applied.

Continued on next page

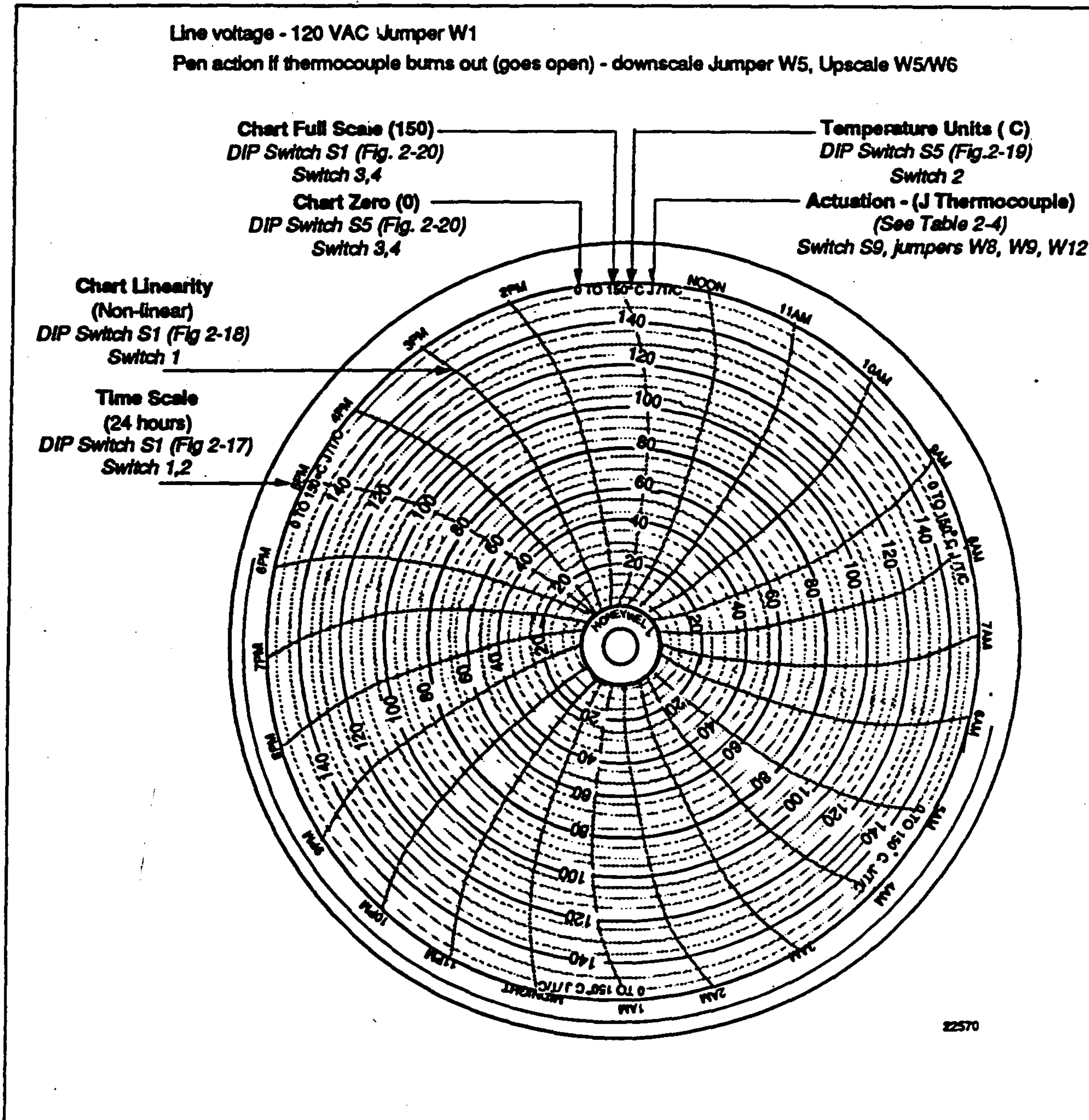
Sample chart

Figure 2-1 is a sample chart for a one-pen recorder.

The configuration selections noted in this figure are taken from the sample chart. It tells you which switch and jumper settings are affected by each.

Figure 2-2 shows the worksheet switch setting based on the sample chart.

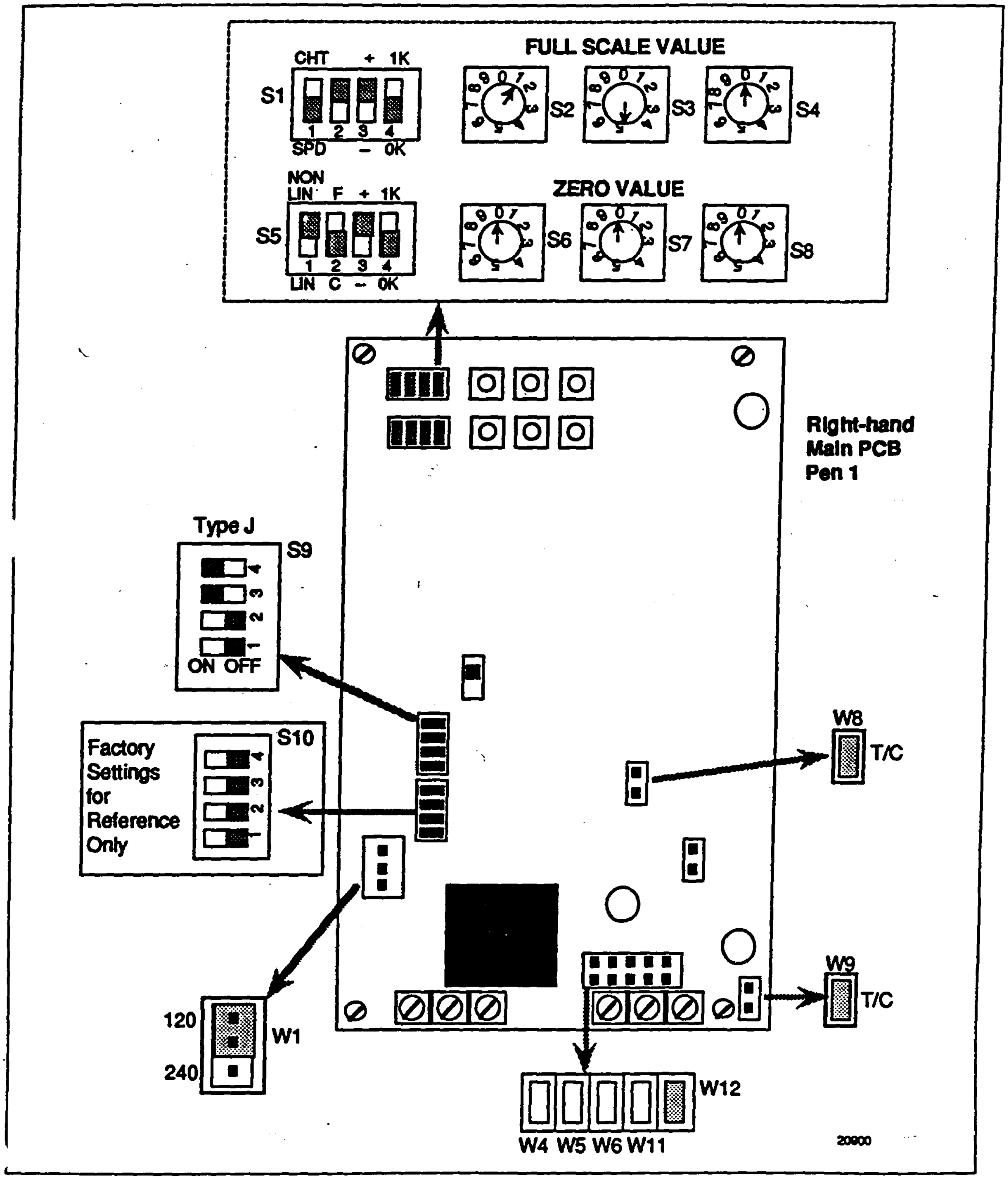
Figure 2-1 Sample Chart for One-Pen Recorder



2.3 Sample Configuration Worksheet for Recording

Sample worksheet Figure 2-2 is a sample Configuration Worksheet for the one-pen recorder chart shown in Figure 2-1.

Figure 2-2 Sample Configuration Worksheet for One-Pen Recorder.

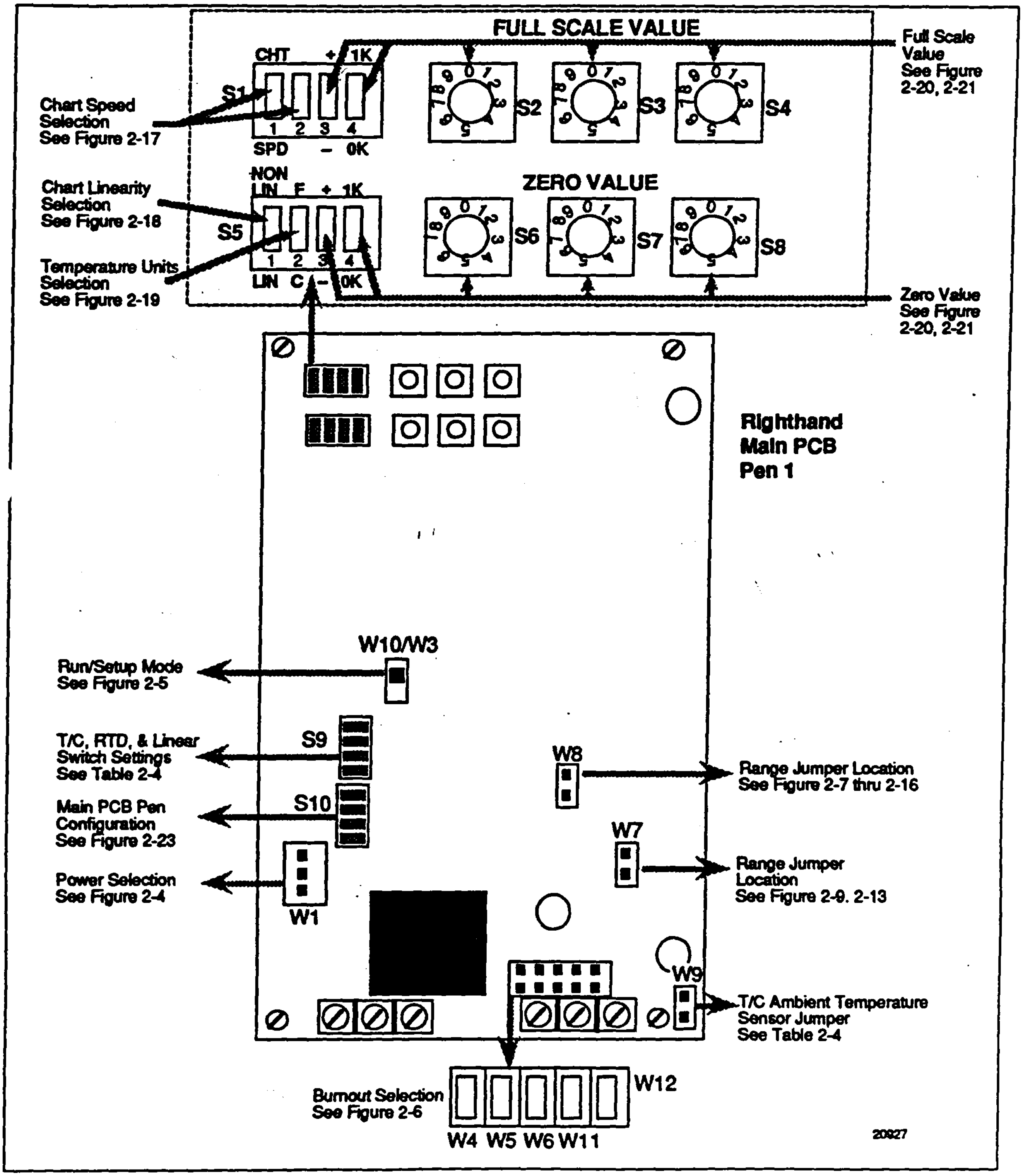


2.4 Overview of Main PCB DIP Switches and Jumper Locations

Introduction

Figure 2-3 is an overview of the DIP switch and jumper locations. Each location references a figure or table that contains the information you need to check or set the switches and jumpers.

Figure 2-3 DIP Switch and Jumper Locations



2.5 Checking Line Voltage Requirements

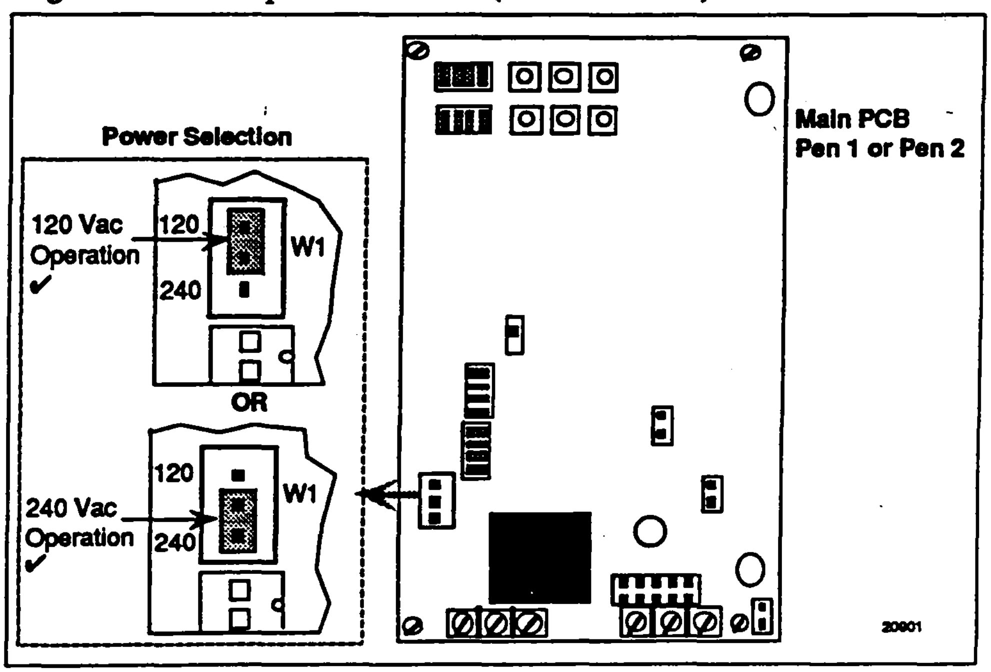
Introduction

Refer to Figure 2-4 and follow the procedure in Table 2-1 to make sure the recorder's power requirement matches the available AC line power.

Table 2-1 AC Line Power Wiring

Step	Action
1	Open the recorder door. Loosen the captive screw in the chart plate and swing the plate out.
2	Locate Jumper W1 next to the transformer on the left side of the Main printed circuit board for Pen #1. See Figure 2-4
3	Position the jumper as follows: Line Voltage — Jumper Location 120Vac 50/60 Hz — 120 (factory setting) 240Vac 50/60 Hz — 240
CAUTION	Be sure Jumper 1 on the Main printed circuit board for Pen #2 is in the same position.
4	If the jumper W1 position is set for 240, be sure to note power requirement on the label on the front of the chart plate.

Figure 2-4 Jumper W1 Positions (AC Line Power)



2.6. Putting the Recorder in the Run or Set Up Mode

oduction

You can put the recorder in the normal RUN mode or the SETUP mode.

SETUP allows you to set DIP switches S9 position 1 to make a pen alignment check (subsection 6.4 and 6.5) or run a self-test. (subsection 5.3).

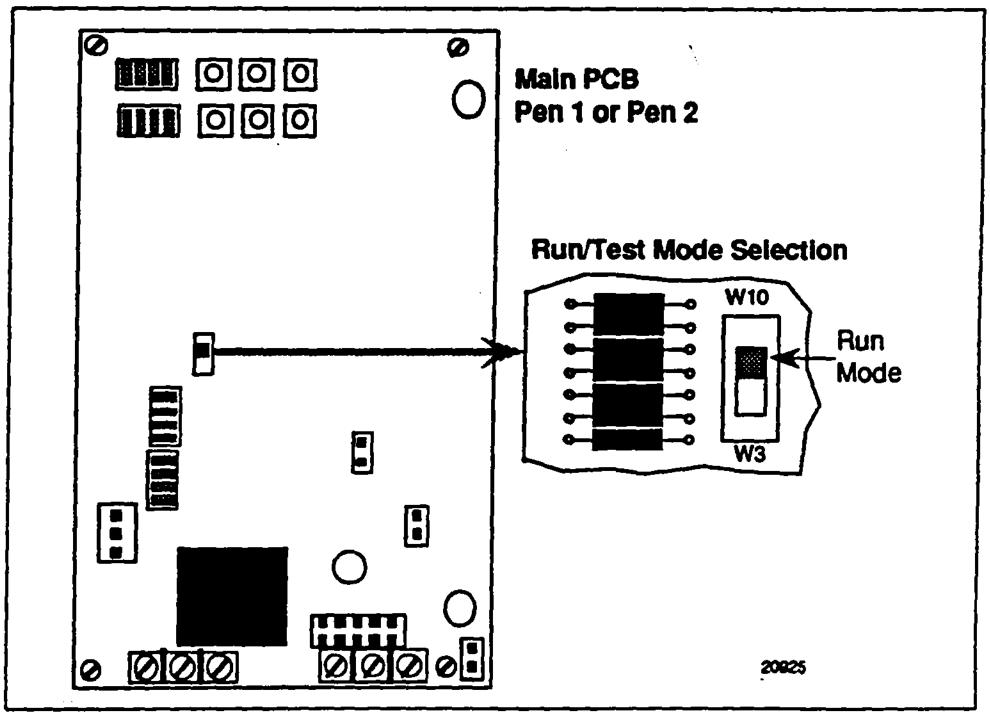
RUN allows you to prepare the recorder for operation. However, you can leave the recorder in the SETUP mode, but it will run the self-test every time power is cycled on/off.

Refer to Figure 2-5 and follow the procedure in Table 2-2 to position slide switch W3/W10 and put the recorder in the RUN mode.

Table 2-2 Switch W3/W10 Positions (Run/Setup Mode)

Step	Action
1	Open the recorder door. Loosen the captive screw in the chart plate and swing the plate out.
2	Locate W3/W10 slide-switch near the left center of the Main printed circuit board for Pen #1 (see Figure 2-5).
3	Check that the slide-switch is in its RUN mode position as follows... Mode of Operation — Switch Position RUN — W10 (UP) SETUP — W3 (DOWN) - factory setting
4	Repeat steps 2 and 3 for Pen #2 Main printed circuit board

Figure 2-5 Switch W3/W10 Positions (Run Mode)



2.7 Selecting Upscale or Downscale Burnout

Introduction

You can select Upscale or Downscale burnout for *Thermocouple* or *Millivolt* actuations. This means that the pen will be driven to its full upscale or downscale position if the Process Variable (PV) goes out-of-range (open input sensor) or the recorder detects a self-check failure.

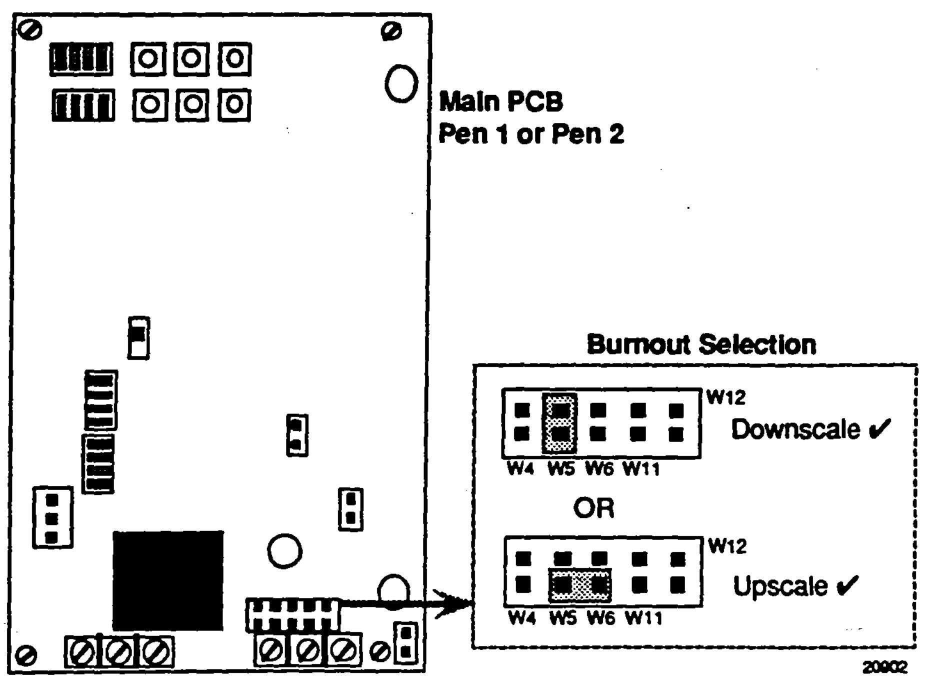
ATTENTION You can select downscale burnout for RTD, Voltage, and mA actuations, but there is no guarantee that an out-of-range PV condition will be detected.

Refer to Figure 2-6 and follow the procedure in Table 2-3 to position jumpers W5 or W6 to select upscale or downscale burnout.

Table 2-3 Jumpers W5 or W6 Positions (Burnout)

Step	Action
1	Open the recorder door. Loosen the captive screw in the chart plate and swing the plate out.
2	Locate W5 and W6 jumpers near the left center of the Main printed circuit board for Pen #1 (see Figure 2-6).
3	Position the jumper as follows... Burnout Direction — Jumper Location Downscale — W5 Upscale — W5/W6 None — None (factory setting)
4	Repeat steps 2 and 3 for Pen #2 Main printed circuit board

Figure 2-6 Jumpers W5/W6 Positions (Burnout)



2.8 Selecting the Input Actuation Type/Range

Introduction

You must configure the recorder to accept the desired input actuation for the given pen by setting DIP switch S9 positions and positioning the applicable range jumpers on the Main printed circuit boards for Pen #1 and Pen #2, if applicable.

Refer to Table 2-4 to identify DIP switch settings and range jumper positions for the desired actuation type.

Refer to the figure number listed in Table 2-4 for your particular actuation. It gives you a graphic view of the DIP Switch settings and jumper positions that are noted in the table for your particular requirement.

Note the configured actuation type for each pen on the wiring label on the back of the chart plate.

ATTENTION Be sure that a matching sensor input is wired to the input terminals.

DIP switch settings and jumper locations

Table 2-4 is a list of actuations, S9 switch positions and settings, range jumper locations, and reference figure numbers.

Table 2-4 Actuation Switch Settings and Jumper Locations

Actuation	Type	S9 Switch Positions and Settings			Range Jumper Locations	Refer to Figure
		2	3	4		
Thermocouple	J	OFF	ON	ON	W8, W9, W12	2-7
Thermocouple	K	OFF	ON	OFF	W8, W9, W12	2-8
Thermocouple	T	OFF	OFF	ON	W7, W9, W12	2-9
RTD*	100 Ohm*	OFF*	OFF*	OFF*	W6, W8, W12*	2-10
Linear	0-20mA	ON	OFF	OFF	W4, W8, W11	2-11
Linear	4–20 mA	ON	OFF	ON	W4, W8, W11	2-12
Linear	0–20 mV	ON	ON	ON	W7, W12	2-13
Linear	0–50 mV	ON	ON	OFF	W8, W12	2-14
Linear	0–5 Vdc	ON	OFF	OFF	W8, W11	2-15
Linear	1–5 Vdc	ON	OFF	ON	W8, W11	2-16

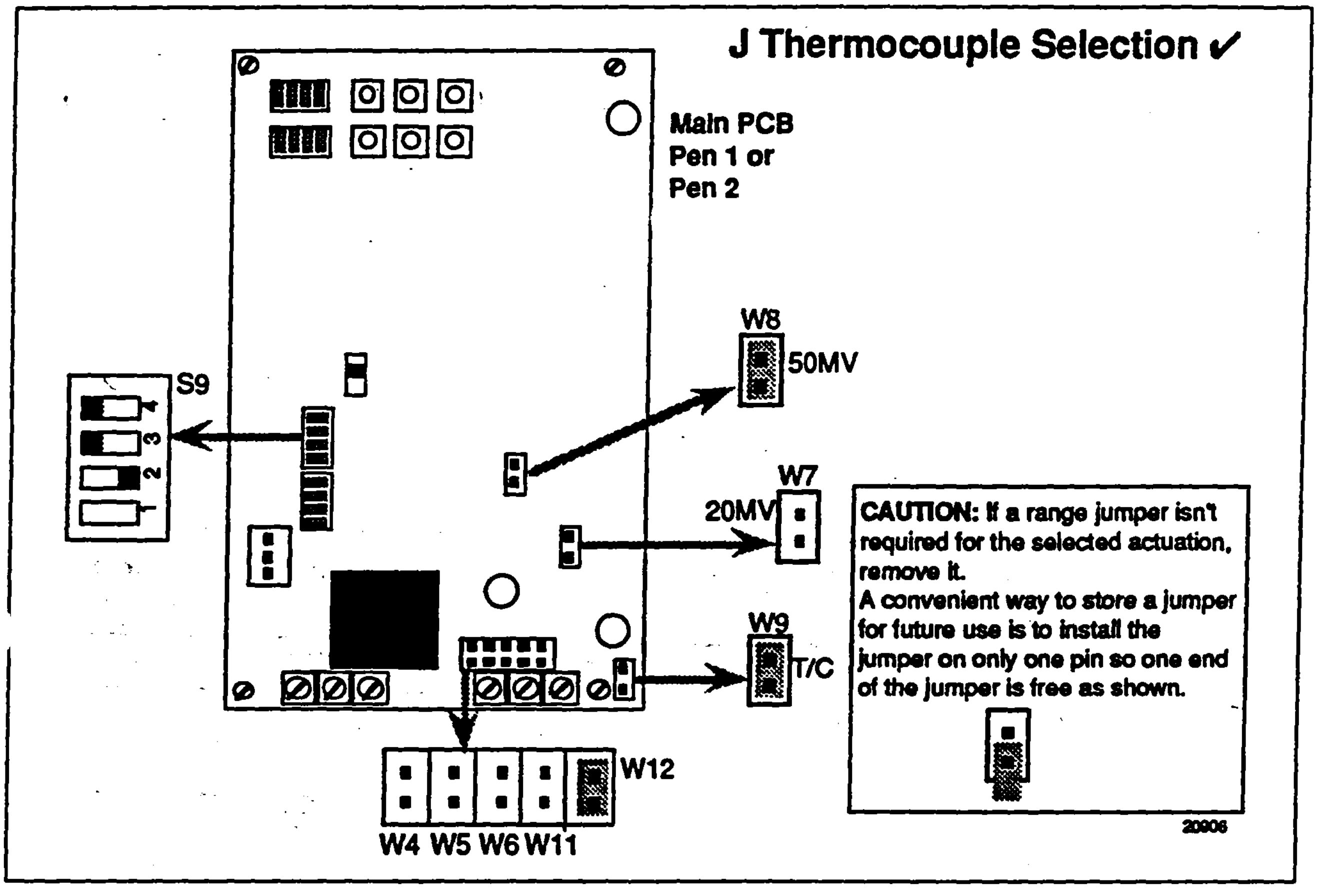
* Factory setting

Continued on next page

Type J thermocouple

Figure 2-7 is a graphic view of the S9 DIP switch settings and jumper locations for type J thermocouple actuation. Make the settings as shown in this figure.

Figure 2-7 Type J Thermocouple Actuation Switch and Jumpers



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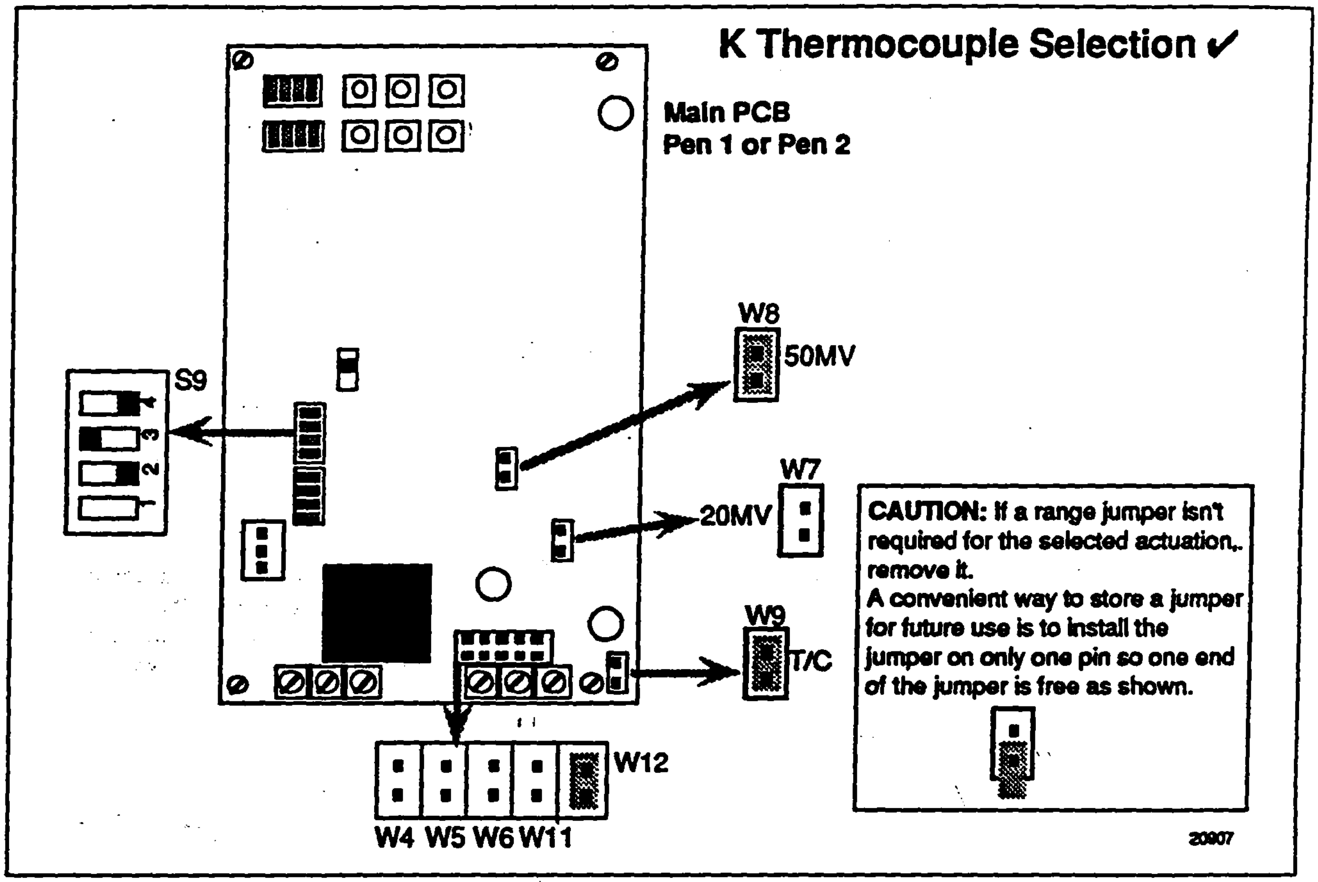
Type K thermocouple

Figure 2-8 is a graphic view of the S9 DIP switch settings and jumper locations for type K thermocouple actuation. Make the settings as shown in this figure.

Figure 2-8 Type K Thermocouple Actuation Switch and Jumpers



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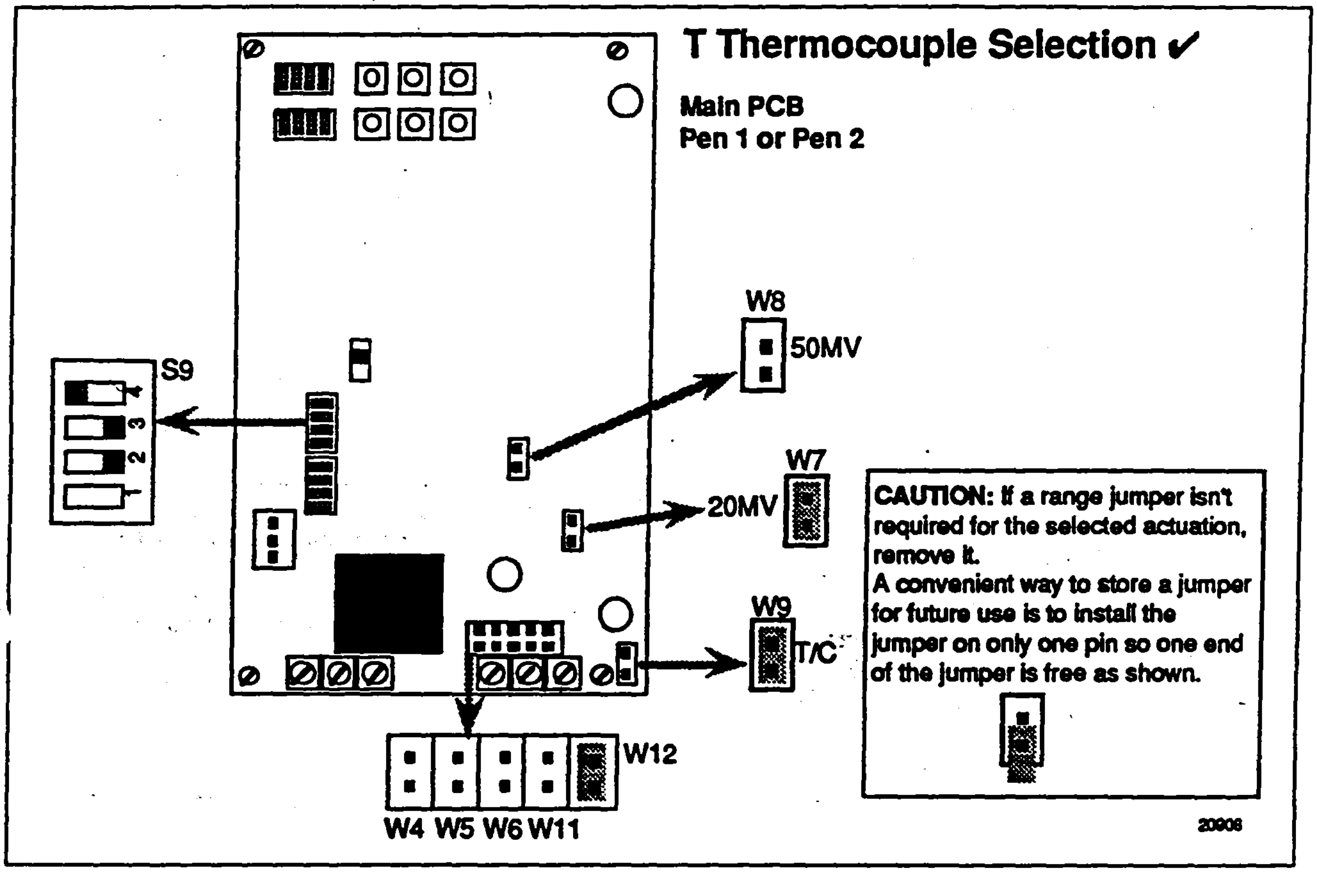
Type T thermocouple

Figure 2-9 is a graphic view of the S9 DIP switch settings and jumper locations for type T thermocouple actuation. Make the settings as shown in this figure.

Figure 2-9 Type T Thermocouple Actuation Switch and Jumpers



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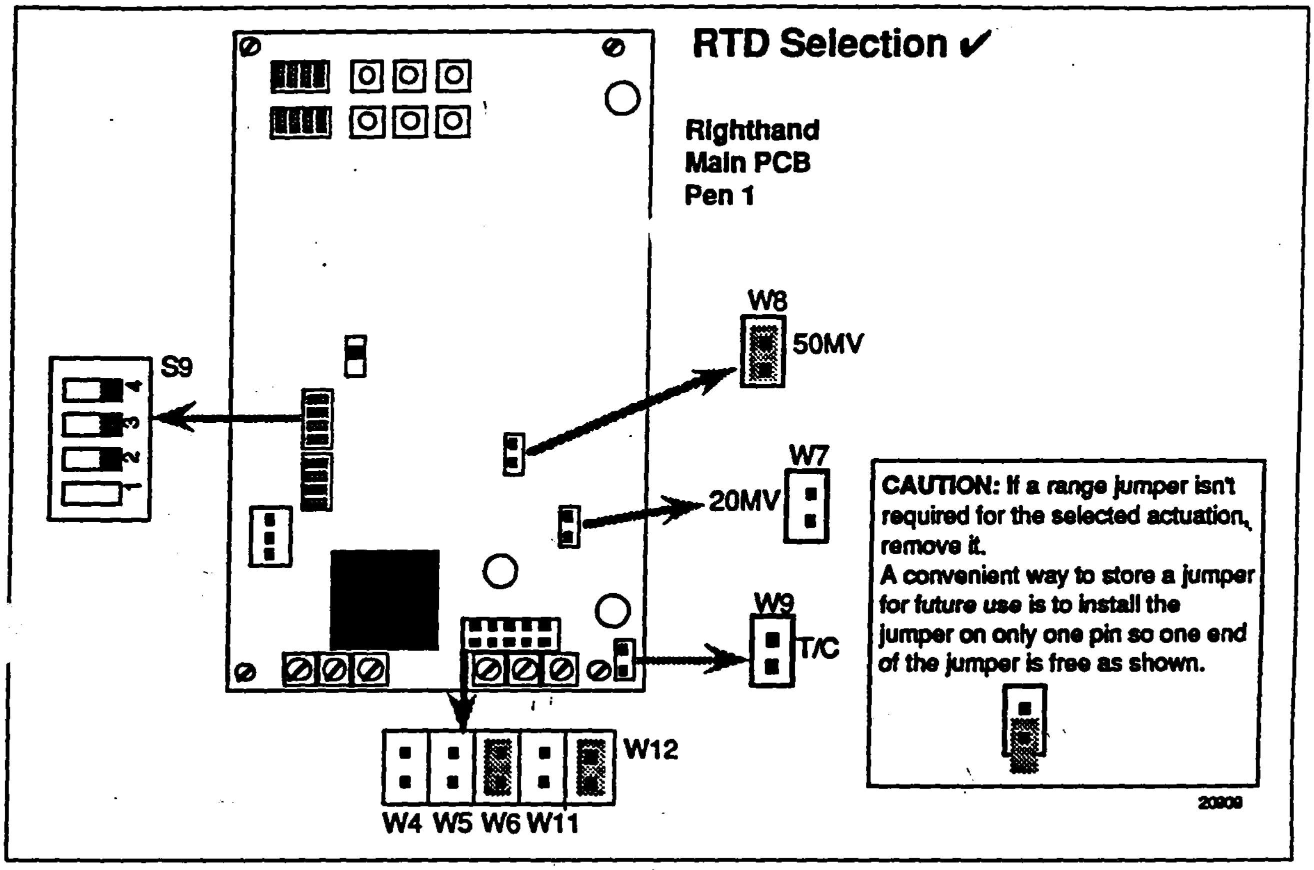
Type RTD

Figure 2-10 is a graphic view of the S9 DIP switch settings and jumper locations for type RTD (Resistance Thermometer Device) actuation. Make the settings as shown in this figure.

Figure 2-10 Type RTD Actuation Switch and Jumpers

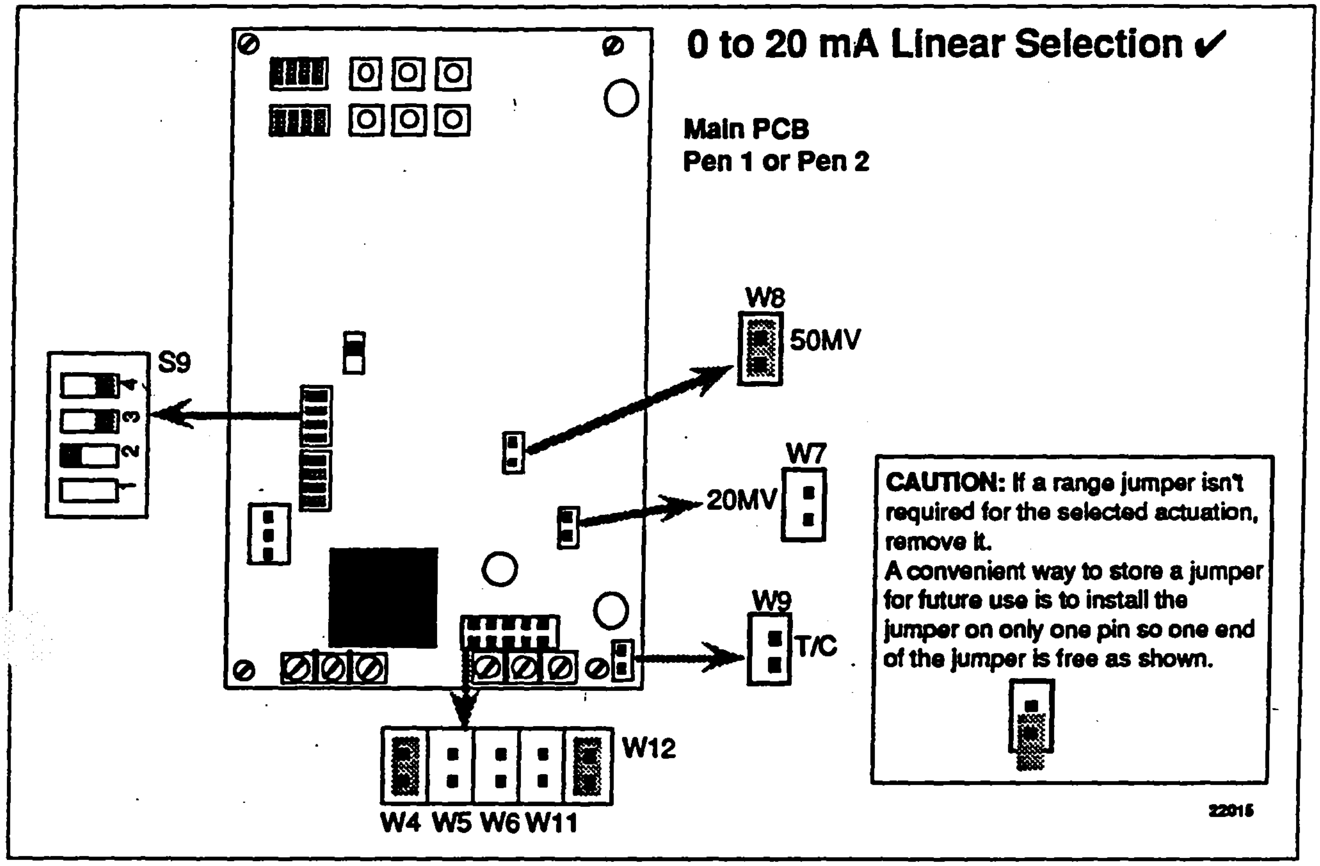


Continued on next page

…e 0–20 mA linear

Figure 2-11 is a graphic view of the S9 DIP switch settings and jumper locations for type 0–20 mA linear actuation. Make the settings as shown in this figure.

Figure 2-11 Type 0–20 mA Linear Actuation Switch and Jumpers

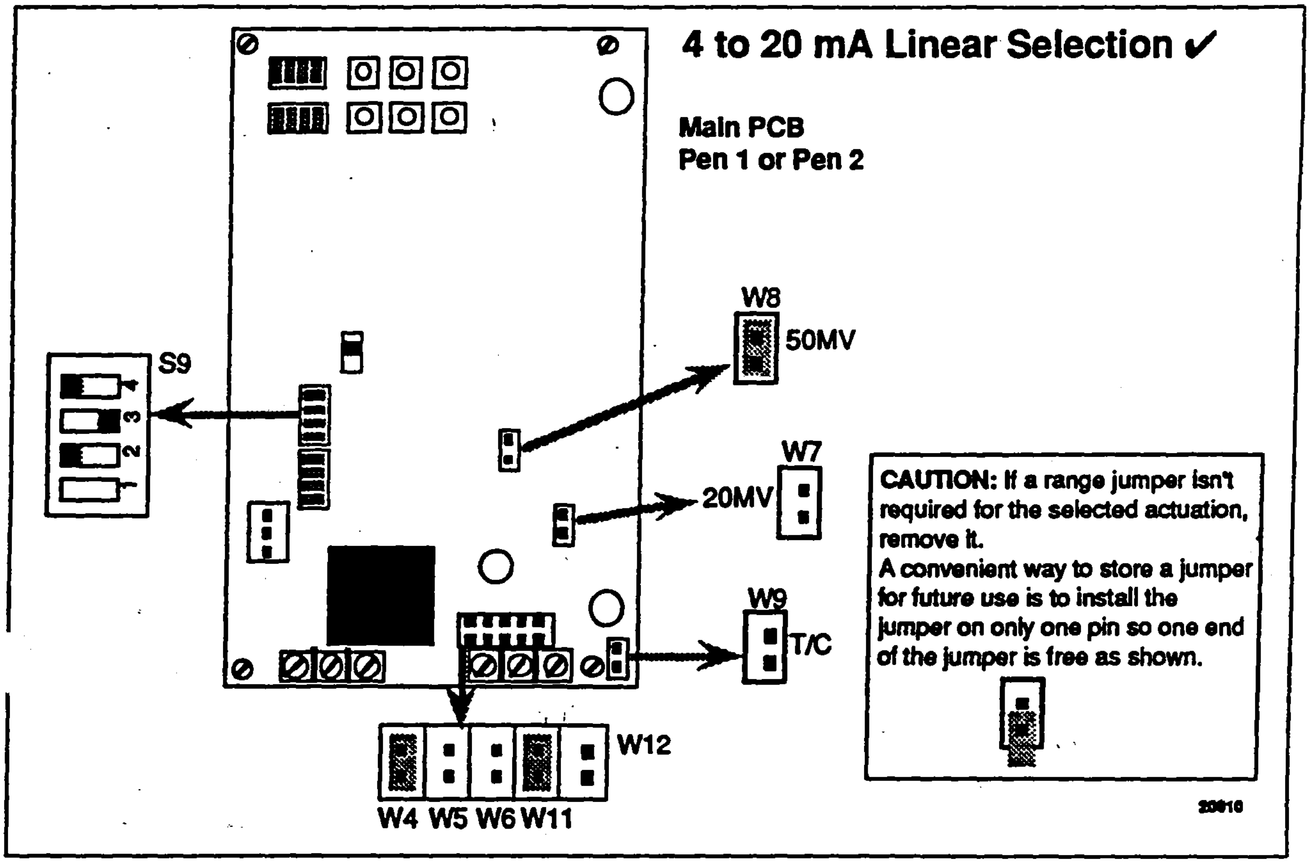


Continued on next page

pe 4–20 mA linear

Figure 2-12 is a graphic view of the S9 DIP switch settings and jumper locations for type 4–20 mA linear actuation. Make the settings as shown in this figure.

Figure 2-12 Type 4–20 mA Linear Actuation Switch and Jumpers



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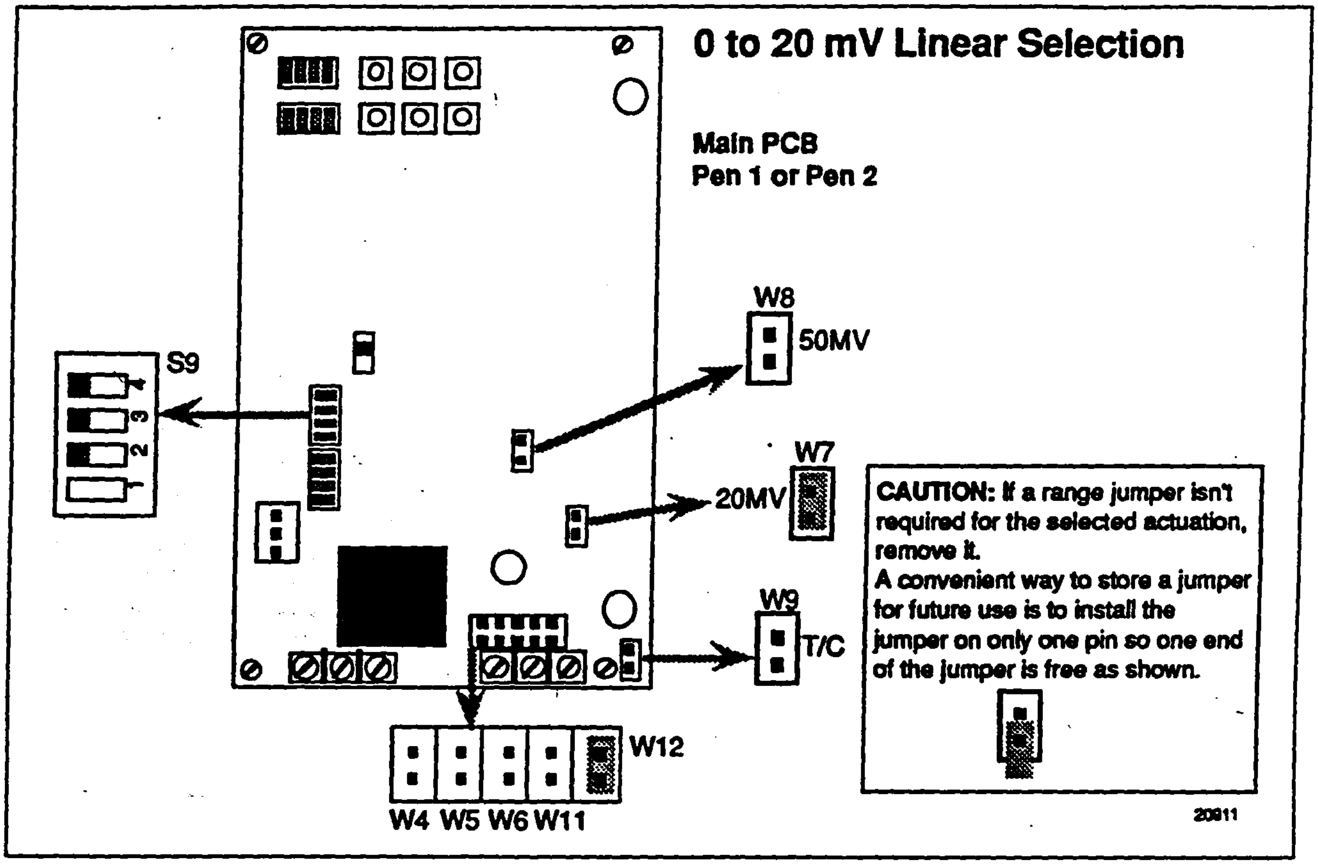
Type 0–20mV linear

Figure 2-13 is a graphic view of the S9 DIP switch settings and jumper locations for type 0–20 mV linear actuation. Make the settings as shown in this figure.

Figure 2-13 Type 0–20 mV Linear Actuation Switch and Jumpers

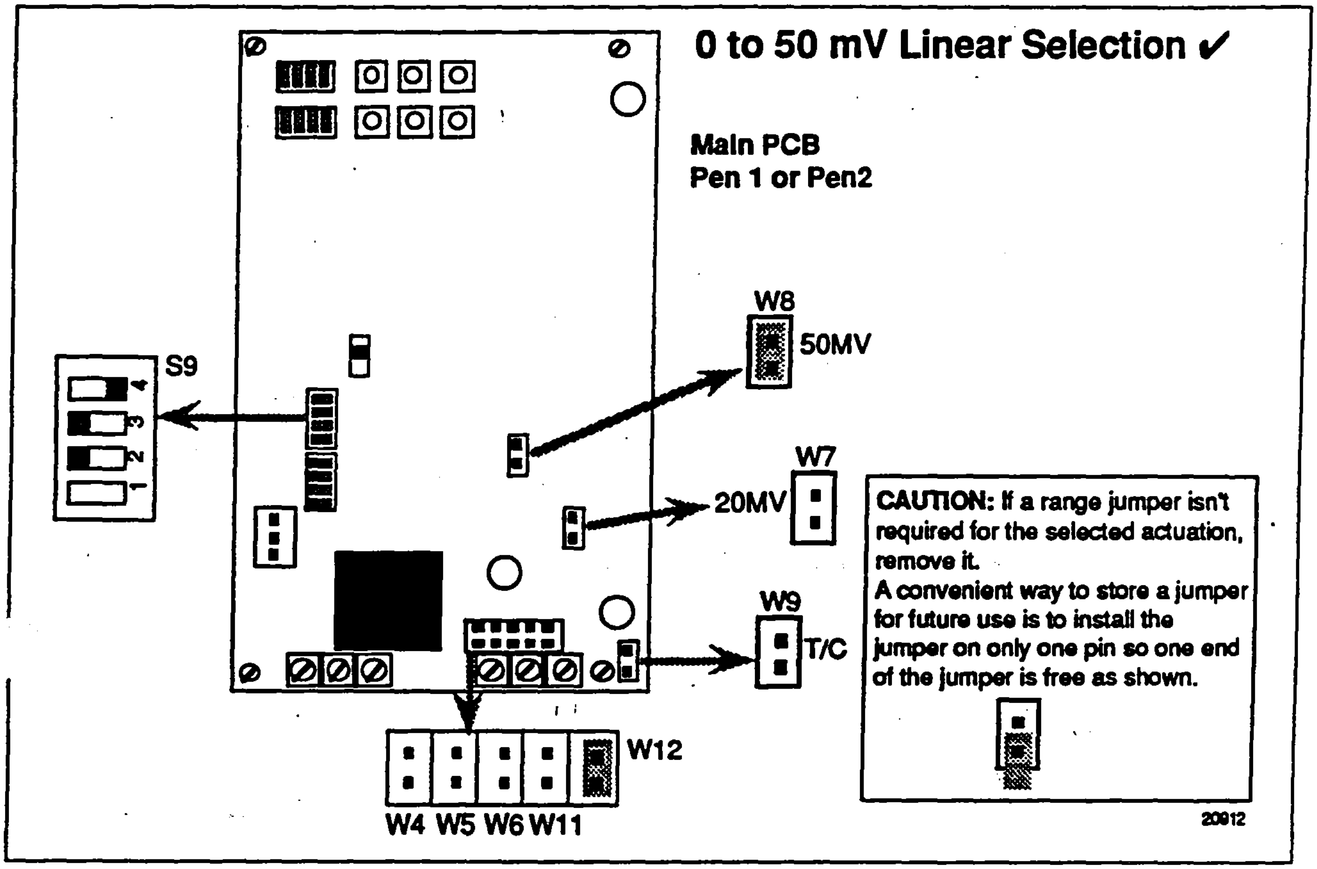


Continued on next page

pe 0–50mV linear

Figure 2-14 is a graphic view of the S9 DIP switch settings and jumper locations for type 0–50 mV linear actuation. Make the settings as shown in this figure.

Figure 2-14 Type 0–50 mV Linear Actuation Switch and Jumpers



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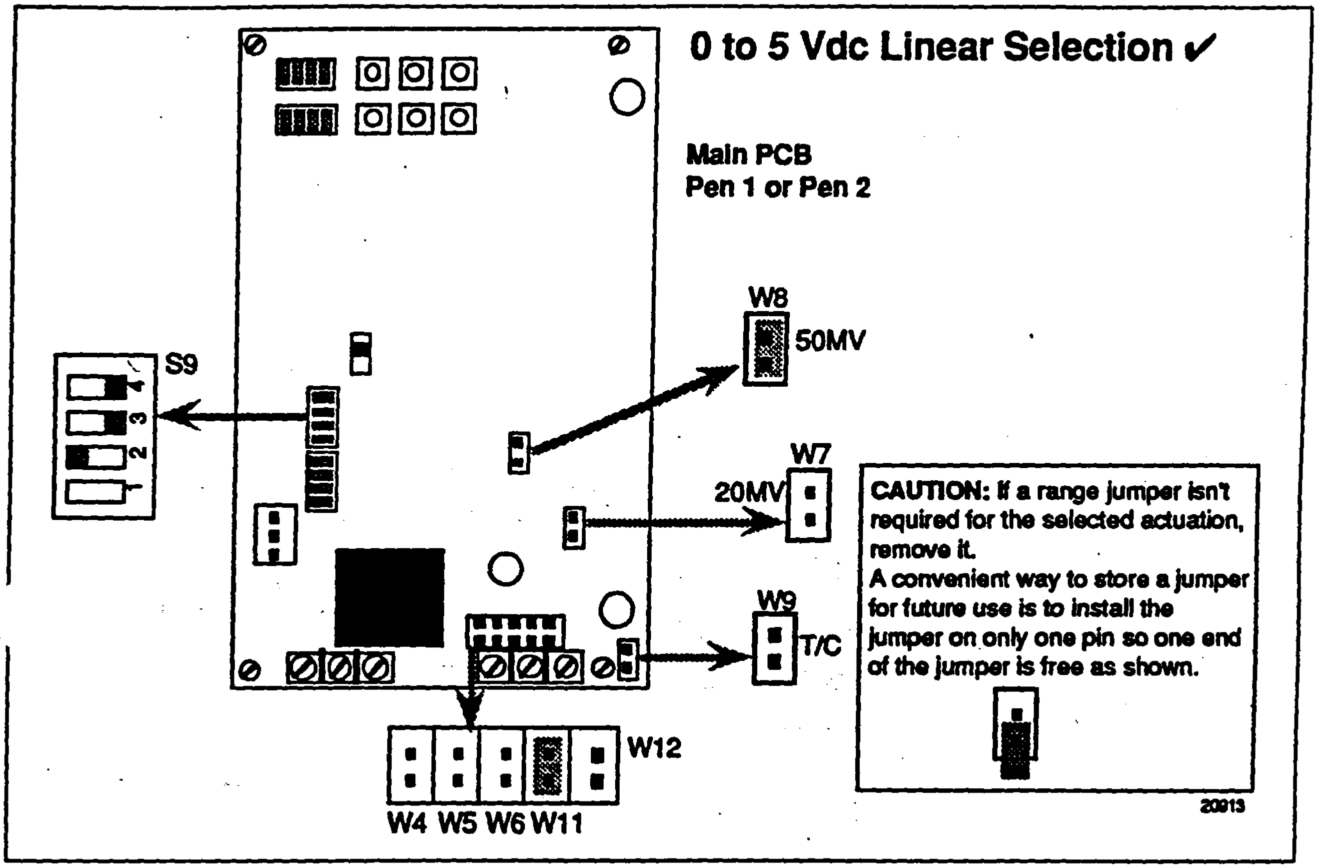
2.8 Selecting the Input Actuation Type/Range, Continued

Type 0–5 Vdc linear Figure 2-15 is a graphic view of the S9 DIP switch settings and jumper locations for type 0–5 Vdc linear actuation. Make the settings as shown in this figure.

Figure 2-15 Type 0–5 Vdc Linear Actuation Switch and Jumpers



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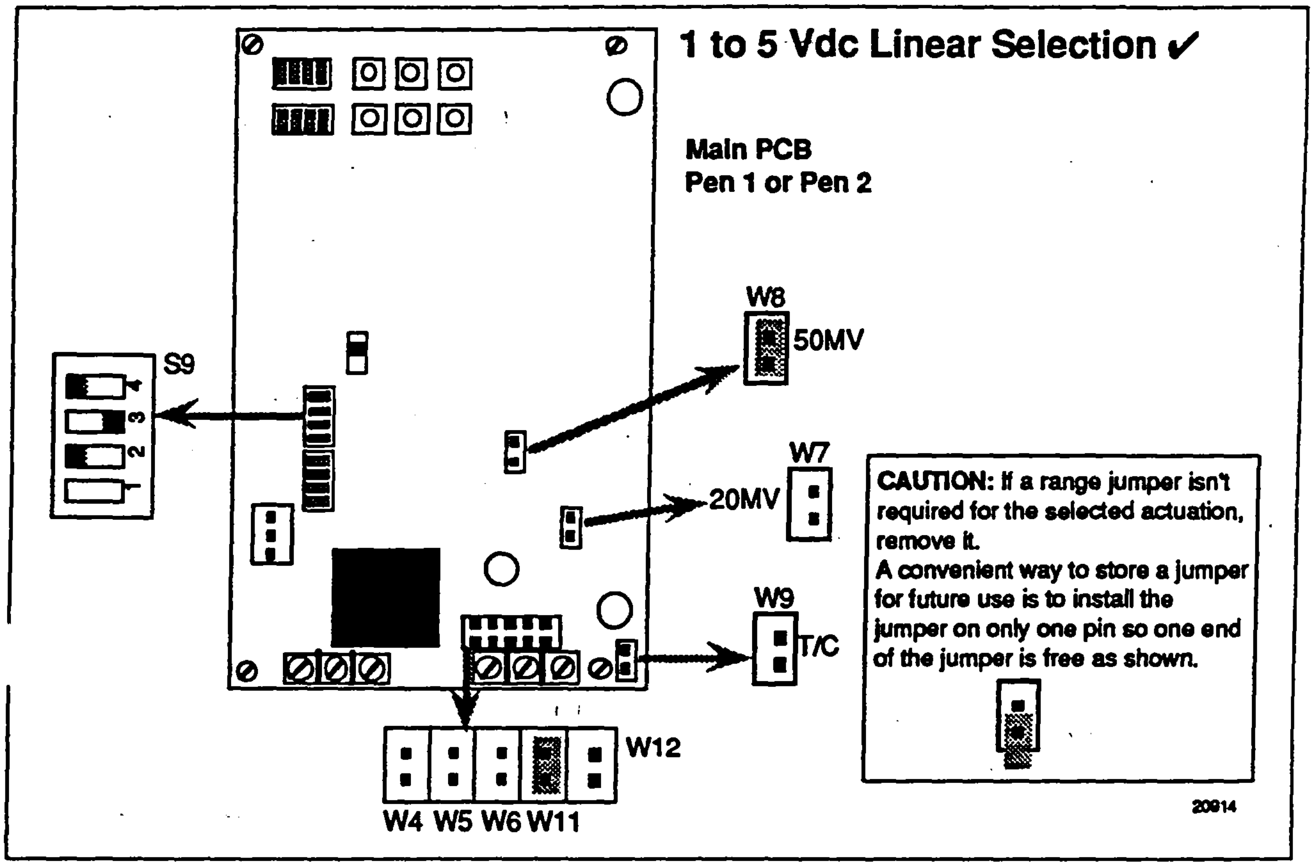
Type 1–5 Vdc linear

Figure 2-16 is a graphic view of the S9 DIP switch settings and jumper locations for type 1–5 Vdc linear actuation. Make the settings as shown in this figure.

Figure 2-16 Type 1–5 Vdc Linear Actuation Switch and Jumpers



2.9 Setting the Chart Speed

Introduction

You can set the time it takes the chart to travel one complete revolution by setting DIP Switch S1 positions 1 and 2 on the Main printed circuit board for Pen #1.

ATTENTION The chart speed setting does not apply for DIP switch S1 on Main printed circuit board for Pen #2.

Refer to Table 2-5 to identify DIP switch settings and range jumper positions for the desired chart speed.

Refer to Figure 2-17 to set your particular chart speed. It gives you a graphic view of the DIP switch settings and jumper positions that are noted in the table.

Switch S1 positions

Table 2-5 is a list of the chart speed switch positions and settings.

Table 2-5 Chart Speed Switch Settings

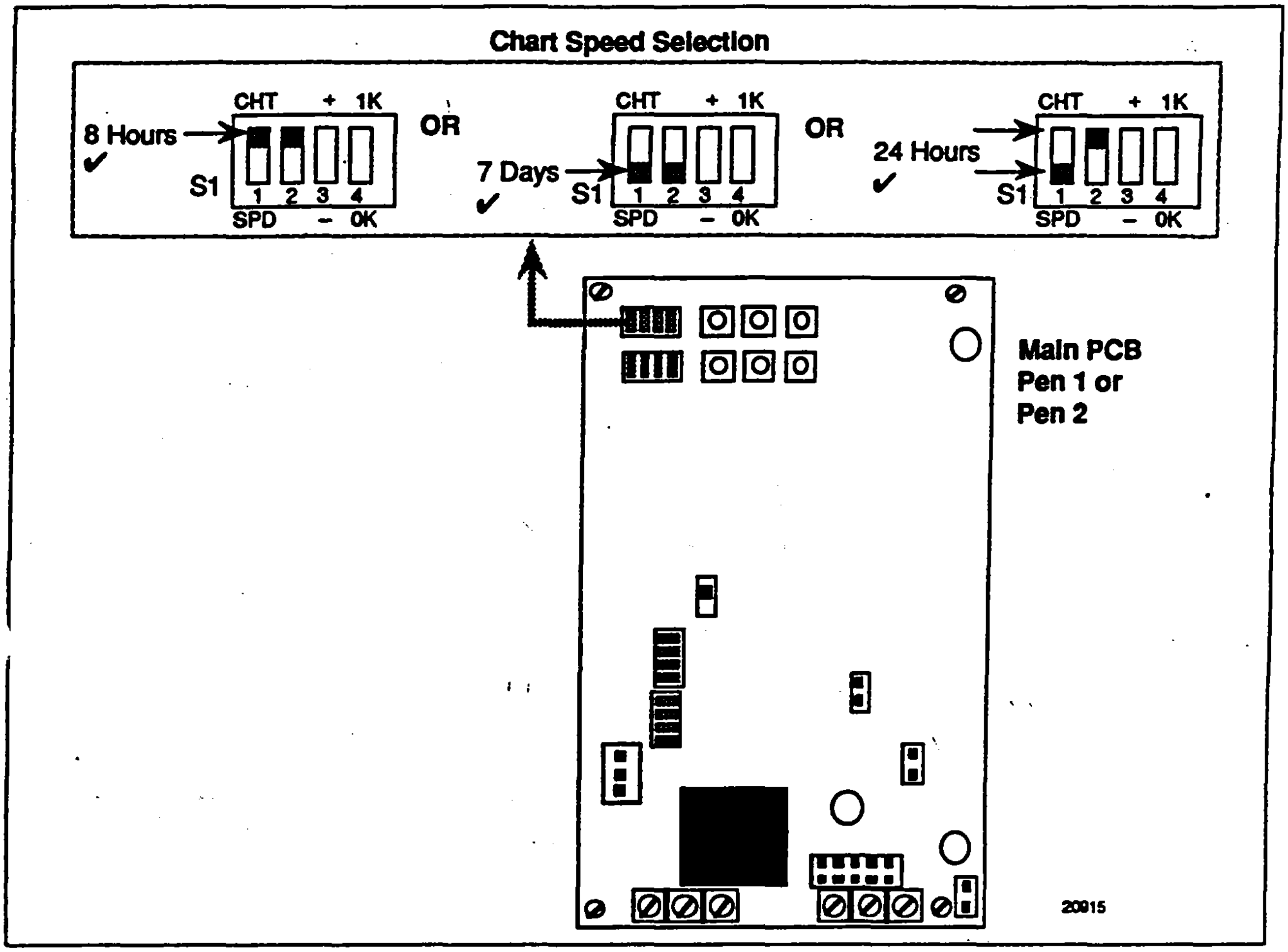
Chart Speed (Time for one revolution)	S1 Switch Position & Settings	
	1	2
8 Hours	ON	ON
Test (For factory use only)	ON	OFF
24 Hours (Factory setting)	OFF	ON
7 Days	OFF	OFF

Continued on next page

Charts speed switch settings

Figure 2-17 is a graphic view of the S1 DIP switch settings and jumper locations for your chart speed. Make a setting for your desired chart speed as shown in this figure.

Figure 2-17 Chart Speed Switch Settings



2.10 Selecting Linear or Nonlinear Chart

Introduction

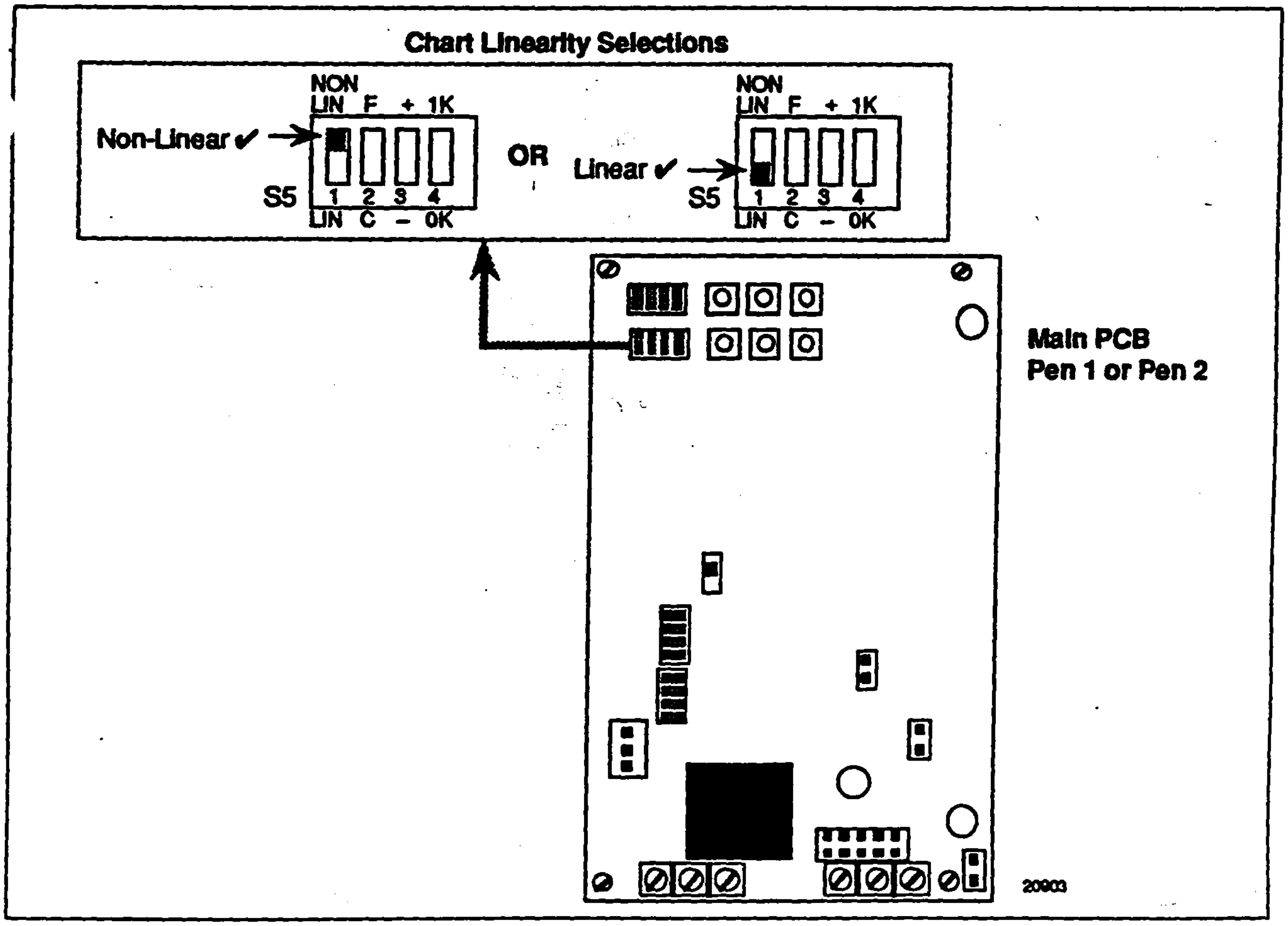
You can specify if the input signals are to be recorded on a Linear (for example: even 100 division), or Nonlinear (for example: Type T thermocouple) chart.

Refer to Figure 2-18 and follow the procedure in Table 2-6 to select a linear or nonlinear chart.

Table 2-6 Linear or Non-Linear Chart

Step	Action
1	Open the recorder door. Loosen the captive screw in the chart plate and swing the plate out.
2	Locate DIP switch S5 in the upper left corner of the Main printed circuit board for Pen #1 (see Figure 2-18).
3	Set position 1 to up/ON if you will be using a nonlinear chart, or down/OFF(factory setting) if you will be using a linear chart. This selection applies to both Pen #1 and Pen #2.

Figure 2-18 Linear or Nonlinear Chart Selection



2.11 Selecting Temperature Units

Introduction

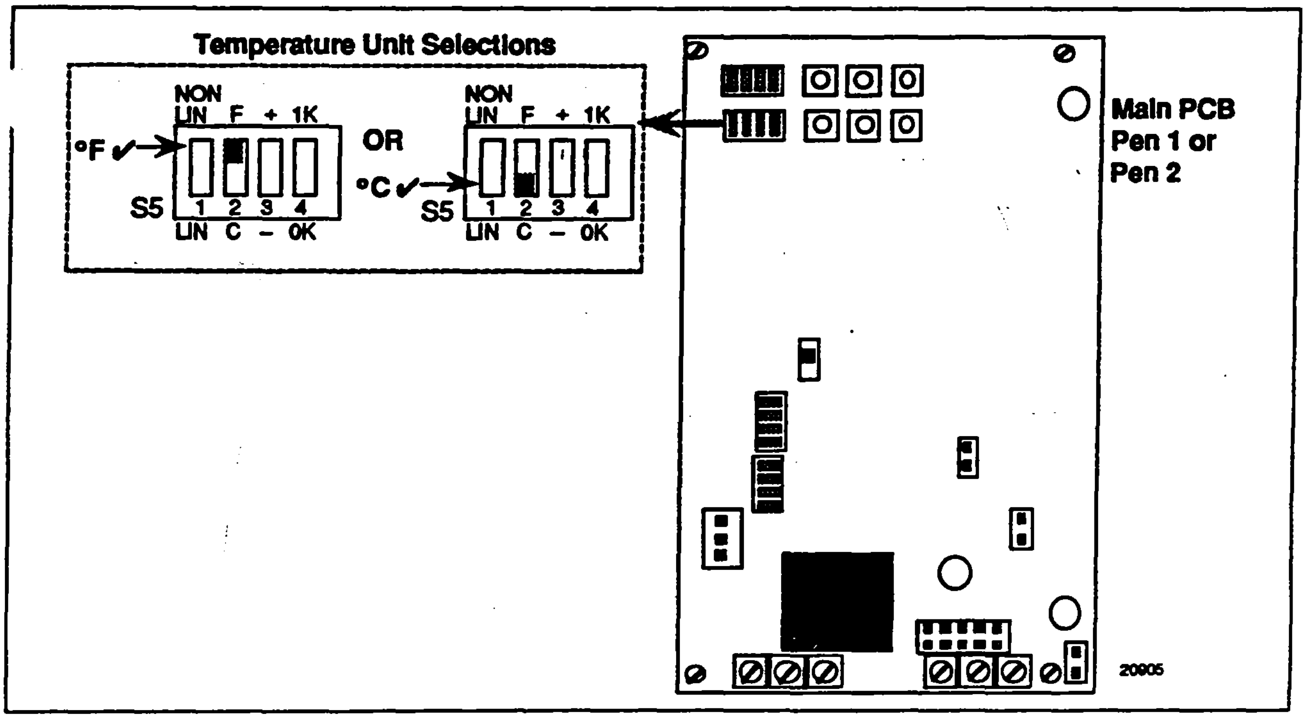
You can select if the temperature unit for the input signal is to be in degrees Fahrenheit or degrees Celsius.

Refer to Figure 2-19 and follow the procedure in Table 2-7 to select a temperature unit.

Table 2-7 Temperature Units Selection

Step	Action
1	Open the recorder door. Loosen the captive screw in the chart plate and swing the plate out.
2	Locate DIP Switch S5 in the upper left corner of the Main printed circuit board for Pen #1 (see Figure 2-19).
3	Set position 2 to up/ON(factory setting) if the input temperature is to be measured in °F, or down/OFF if the input temperature is to be measured in °C. Be sure to check this setting on S5 on the Main printed circuit board for Pen #2 also.

Figure 2-19 Temperature Units Selection



2.12 Setting Chart Zero and Full Scale Values

Introduction

You must set the values that represent the zero and full scale range for the process variable that you are recording.

Refer to Table 2-8 for the actuation minimum and maximum range values.

Refer to Figure 2-20 and follow the procedure in Table 2-9 to set the zero and full scale values of a T/C or RTD actuation.

Refer to Figure 2-21 and follow the procedure in Table 2-10 to set the zero and full scale values of a linear actuation.

Minimum and maximum range values

Table 2-8 lists the minimum and maximum range values for each type actuation listed. Use these values when setting your zero and full scale values.

Table 2-8 Actuation Minimum and Maximum Range Values

Actuation	Type	Range Values		
		°F	°C	Even
Thermocouple	J	0 to 1600	–18 to 871	—
Thermocouple	K	–320 to 1999*	–196 to 1371	—
Thermocouple	T	–300 to 700	–184 to 371	—
RTD	100 Ohm	–300 to 900	–184 to 482	—
Linear	4–20 mA	—	—	0 to 100
Linear	0–20 mV	—	—	0 to 100
Linear	0–50 mV	—	—	0 to 100
Linear	0–5 Vdc	—	—	0 to 100
Linear	1–5 Vdc	—	—	0 to 100

* Limited by switch settings - to use 0 to 2400 °F chart, convert range to –18 to 1316°C.

Continued on next page

T/C or RTD actuations

Refer to Figure 2-20 and follow the procedure in Table 2-9 to set the zero and full scale values of a T/C or RTD actuation.

Table 2-9 Chart Zero and Full Scale Values (T/C or RTD Actuations)

Step	Action
1	Open the recorder door. Loosen the captive screw in the chart plate and swing the plate out.
Full Scale Value	
2	Locate DIP Switch S1 in the upper-left corner of the Main printed circuit board for Pen #1 (see Figure 2-20).
3	Set position 3 to up/ON(factory setting) for positive value or down/OFF for a negative one.
4	Set position 4 to up/ON for one thousand digit or down/OFF(factory setting) for zero thousand digit.
5	Turn the arrow in the center of the rotary DIP switches S2, S3, and S4 to point to the desired number for 100, 10, and 1 digit places in Full Scale value. Figure 2-20 shows an example for –400(zero) and +1000 (full scale)
Zero Scale Value	
6	Locate DIP Switch S5 in the upper left corner of the Main printed circuit board for Pen #1 (see Figure 2-20).
7	Set position 3 to up/ON(factory setting) for positive value or down/OFF for a negative one.
8	Set position 4 to up/ONfor one thousand digit or down/OFF(factory setting) for zero thousand digit.
9	Turn the arrow in the center of the rotary DIP switches S6, S7, and S8 to point to the desired number for 100, 10, and 1 digit places in Zero Scale value. Figure 2-20 shows an example for –400(zero) and +1000 (full scale)

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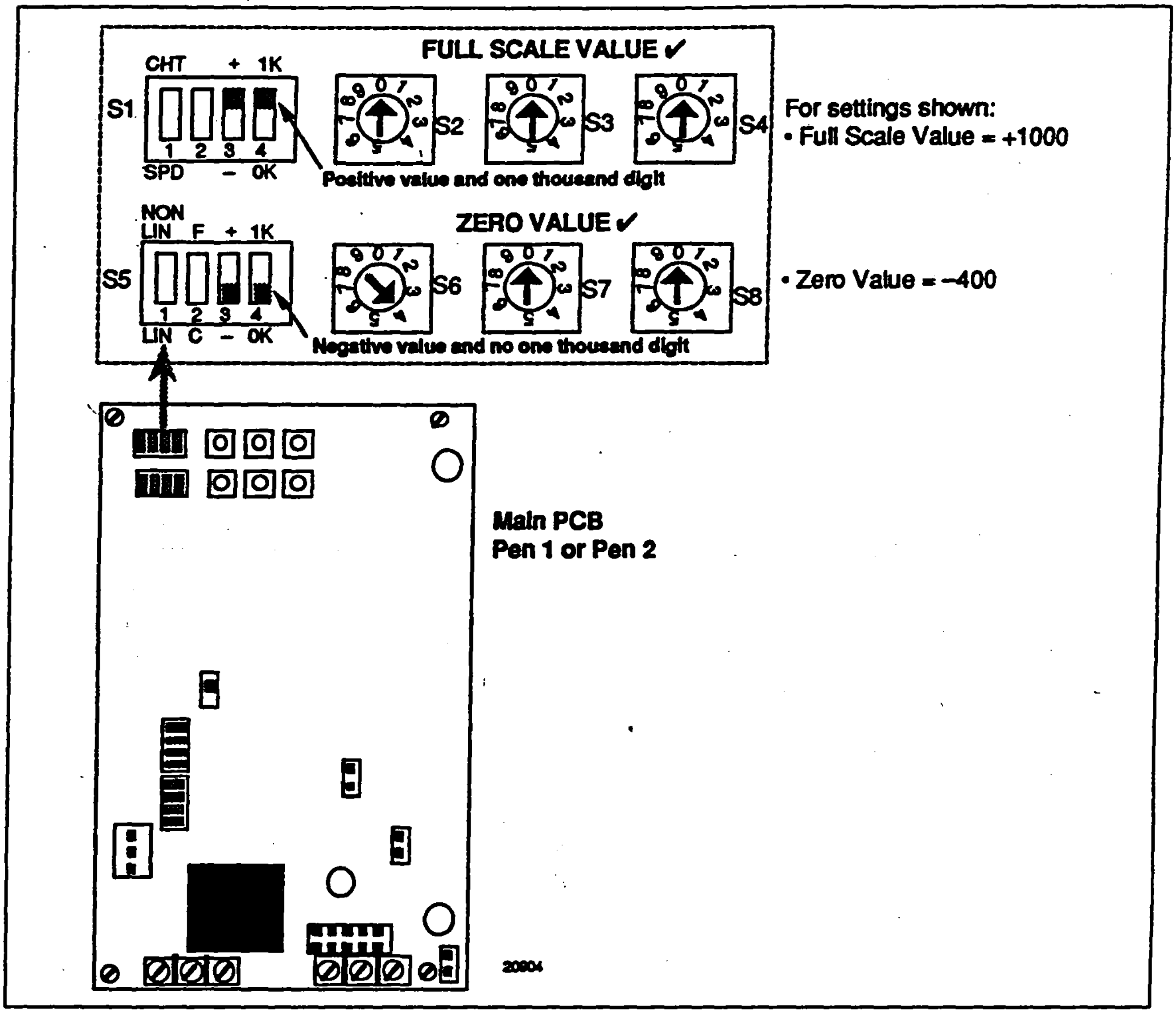
T/C or RTD actuations, continued

Figure 2-20 DIP Switch Settings for Chart Zero and Full-Scale Values (T/C or RTD Actuations)



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Linear actuations

Refer to Figure 2-21 and follow the procedure in Table 2-10 to set the zero and full scale values of a Linear actuation.

Set the scale values as shown in Table 2-10, but multiply settings 1K, 100, 10, and 1 by **0.1**.

The input range for any linear input always equals **0 to 100%**.
For example: with a 4–20mA input, 4mA equals 0% and 20mA equals 100%. Thus, regardless of the printed chart range for the Process Variable being measured, you must set the zero and full scale values based on 0 to 100%.

To narrow the range of measurement, refer to Figure 2-22.

Table 2-10 Chart Zero and Full Scale Values (Linear Actuations)

Step	Action
1	Open the recorder door. Loosen the captive screw in the chart plate and swing the plate out.
Full Scale Value	
2	Locate DIP Switch S1 in the upper left corner of the Main printed circuit board for Pen #1 (see Figure 2-21).
3	Set position 3 to up/ONfor positive value or down/OFF for a negative one.
4	Set position 4 to up/ON) for one thousand digit or down/OFF(factory setting) for zero thousand digit.
5	Turn the arrow in the center of the rotary DIP switches S2, S3, and S4 to point to the desired number for 100, 10, and 1 digit places in Full Scale value. **You must multiply these settings by 0.1.** Figure 2-21 shows an example for +000.0(zero) and +100.0 (full scale).
Zero Scale Value	
6	Locate DIP Switch S5 in the upper-left corner of the Main printed circuit board for Pen #1 (see Figure 2-20).
7	Set position 3 to up/ONfor positive value or down/OFF for a negative one.
8	Set position 4 to up/ONfor one thousand digit or down/OFF(factory setting) for zero thousand digit.
9	Turn the arrow in the center of the rotary DIP switches S6, S7, and S8 to point to the desired number for 100, 10, and 1 digit places in Zero Scale value. **You must multiply these settings by 0.1.** Figure 2-21 shows an example for +000.0(zero) and +100.0 (full scale).

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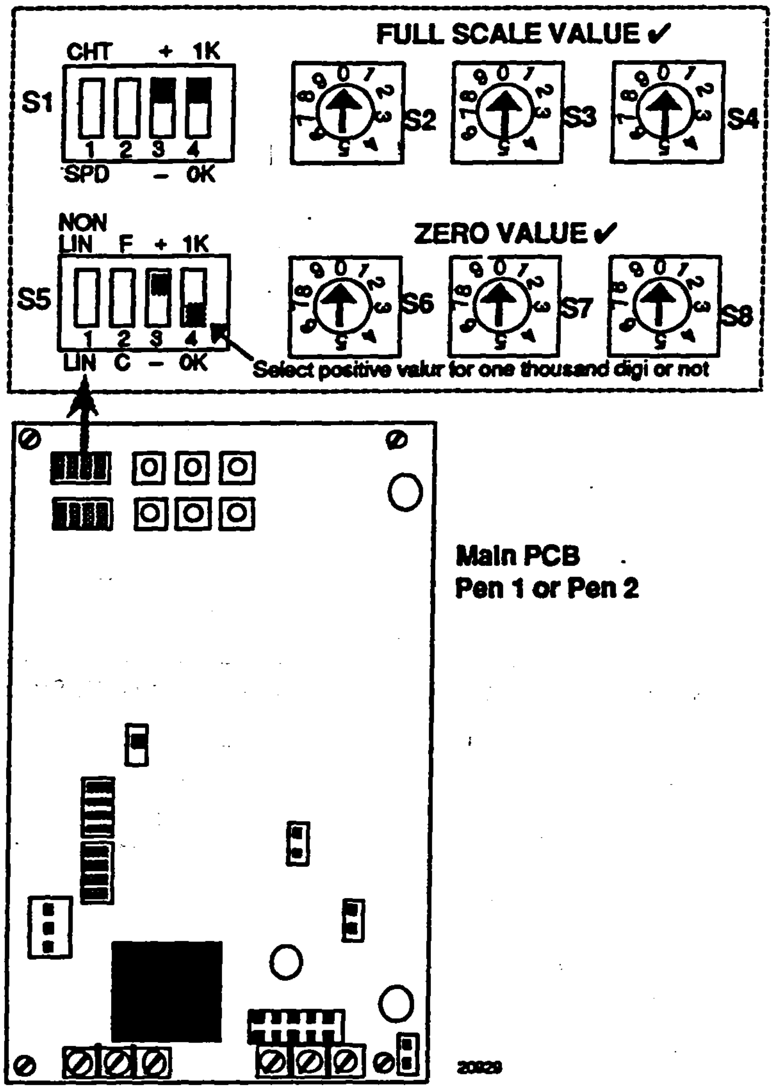
Linear actuations, continued

Figure 2-21 DIP Switch Settings for Chart Zero and Full Scale Values (Linear Actuations)



For settings shown:
- Full Scale Value = +100.0
- Zero Value = +000.0

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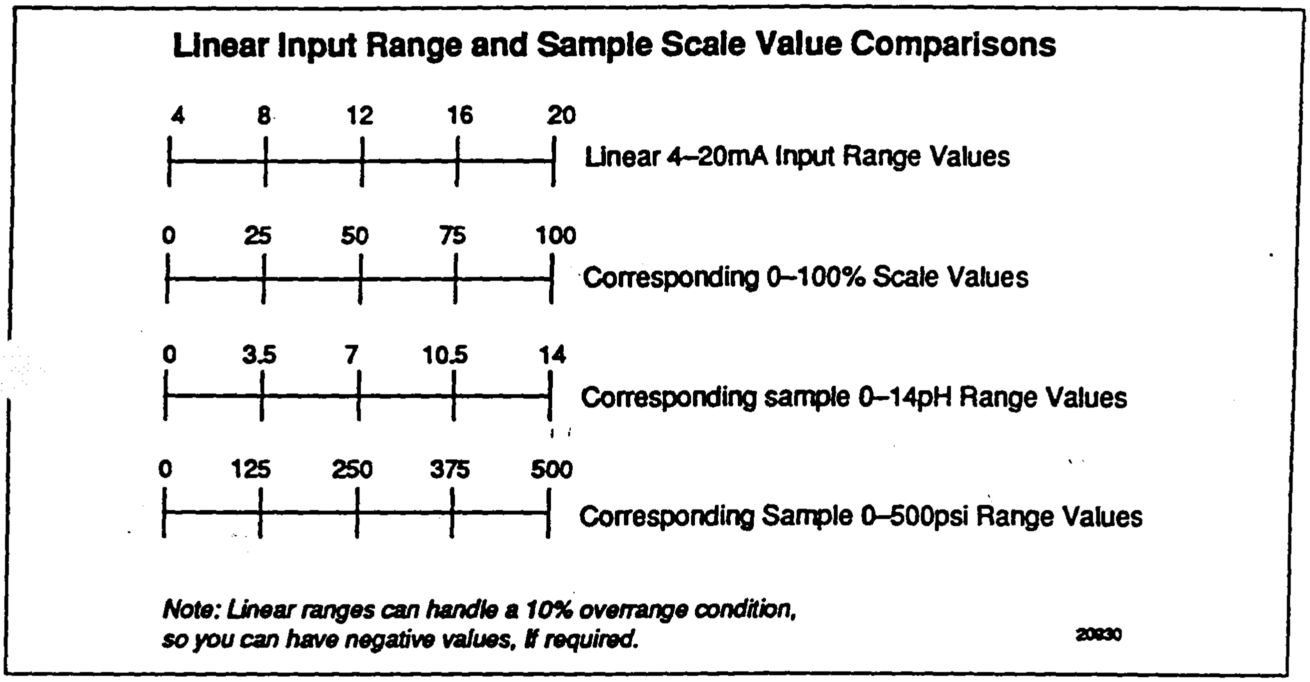
rowing the range of measurement

You can narrow the range of measurement on a linear range by setting the corresponding scale percentage.

For example: if 4 to 20mA is being used to measure 0 to 14pH on a chart graduated for 0 to 14pH, the zero value must be set to 0 and the full scale value must be set to 100 in order to record the full scale range of 0 to 14pH.

You can narrow the range of measurement by setting the corresponding scale percentage. To record values between 3.5 and 10.5pH only, the zero scale value must be set to 25% and the full scale value must be set to 75%. The 25% and 75% values correspond with the 3.5 and 10.5pH measurements within the 0 to 14pH (0 to 100%) range as shown in Figure 2-22.

Figure 2-22 Narrow Range Measurement



2.13 Checking the Main Printed Circuit Board Pen Configuration

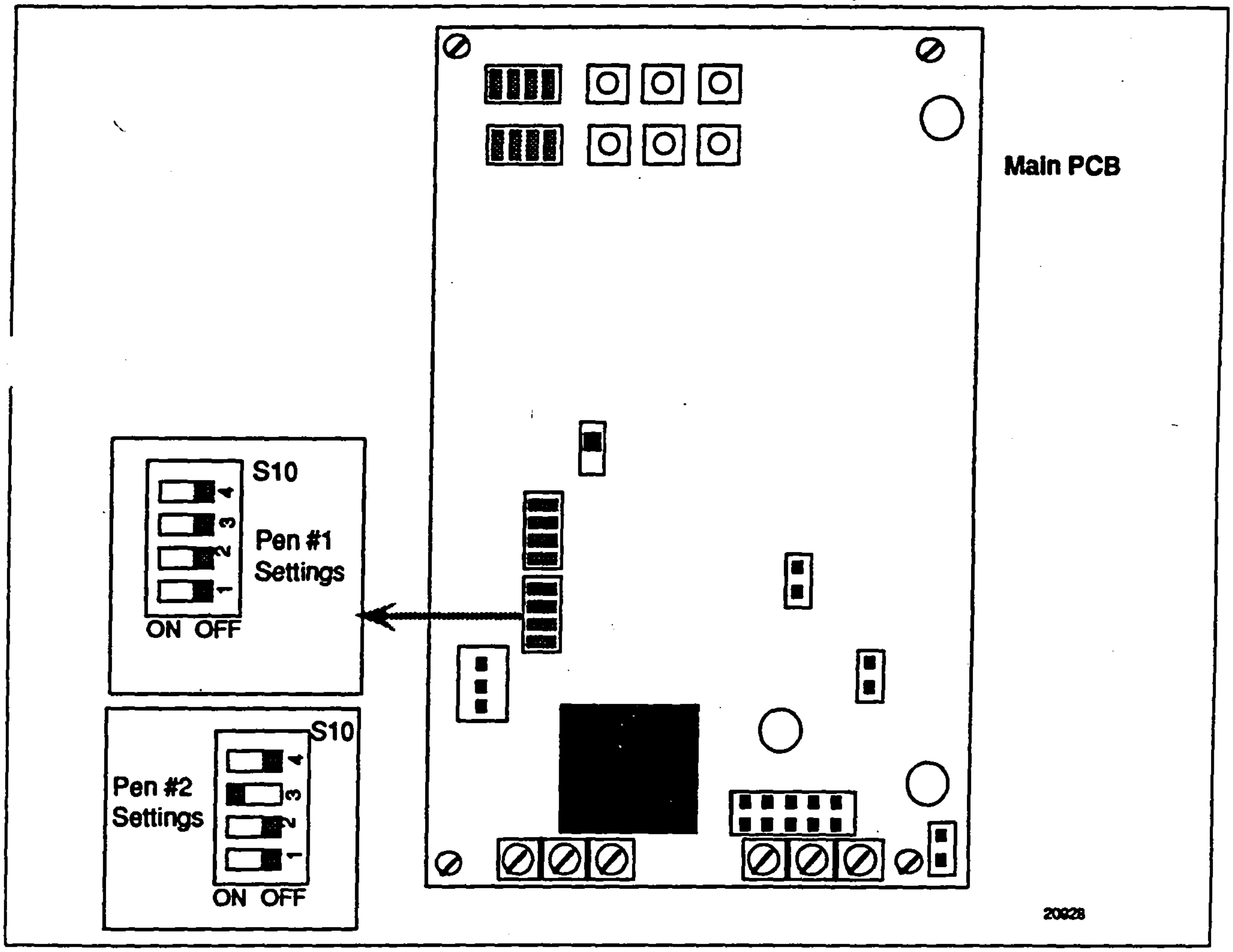
Pen configuration

Since the Main printed circuit board used for Pen #1 is identical to the one used for Pen #2, you must check the DIP switch S10, position 3, to be sure the Main PCB is configured to support the correct pen.

The Main printed circuit board for Pen #1 is always mounted on the right-hand side of the case, and the one for Pen #2 is always mounted on the left-hand side of the case. **The DIP switch is factory set for the correct pen.**

Refer to Figure 2-23 to check the Pen configuration; refer to Figure 2-24 for a Configuration Worksheet for recording pen #1, and to Figure 2-25 for a Configuration Worksheet for recording pen #2..

Figure 2-23 Pen Configuration.



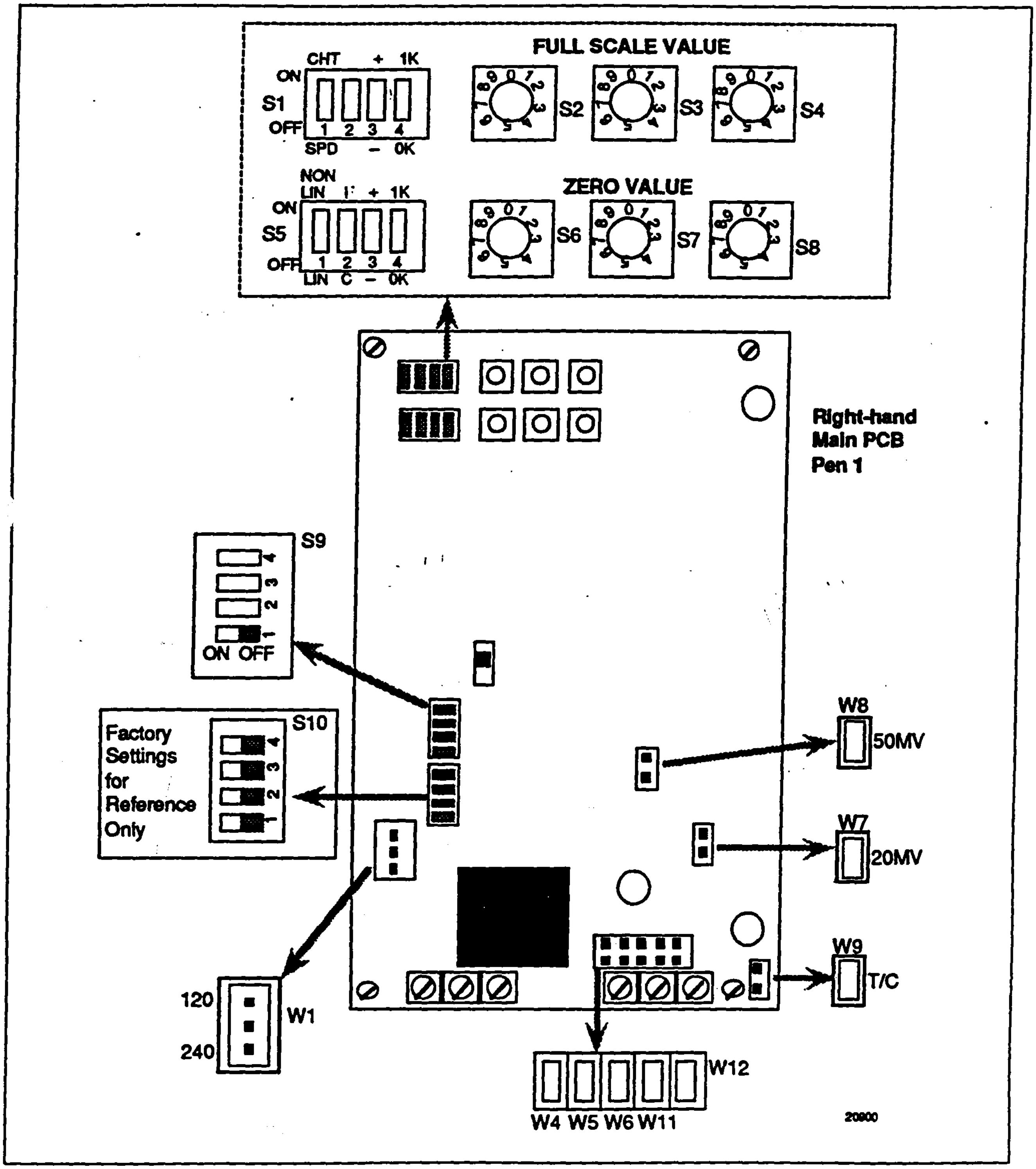
2.14 Configuration Worksheet for Recording Pen #1

Configuration worksheets

Refer to Figure 2-24 for a Configuration Worksheet for recording pen #1, and to Figure 2-25 for a Configuration Worksheet for recording pen #2.

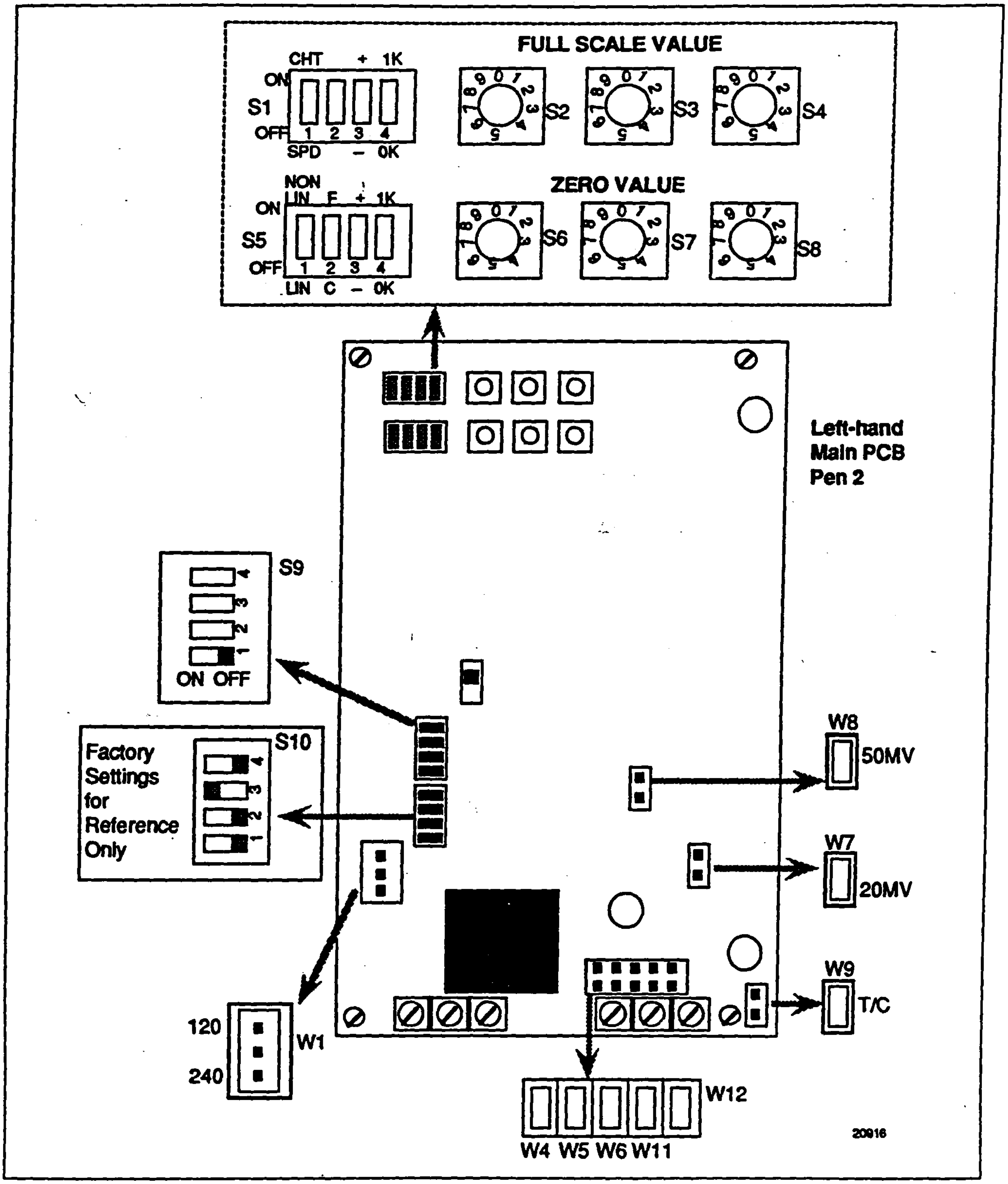
Mark up the worksheets based on your chart selection as shown in the examplw in Figure 2-1.

Figure 2-24 Pen #1 Configuration - DIP Switch Positions



2.15 Configuration Worksheet for Recording Pen #2

Figure 2-25 Pen #2 Configuration - DIP Switch Positions



Section 3 – Optional Relay Output Set Up

3.1 Introduction

Overview

Optional Relay Output Set Up consists of mounting the Output printed circuit board(s) and checking or setting jumper positions and DIP switch selections on each.

This section contains the Set-up tasks required to prepare your recorder for Relay Output operation. Each separate task includes a general overview of that task and a procedure for you to follow to accomplish it. Unless noted, the procedural steps apply for both Relay Output printed circuit boards.

To help you, there is a composite view of the component locations as well as the factory settings for the jumpers and DIP switches

ATTENTION Set up the Main printed circuit board(s) before mounting and checking the jumper positions and DIP switch settings on your Relay Output board. Refer to *Section 2- Recording Set Up* for further information.

What's in this section?

The following topics are covered in this section:

3.2 Configuration Selections for Relay Output

Introduction

If you ordered a recorder with relay output, a separately packaged Output printed circuit board is supplied with your recorder. You must mount the Output printed circuit board on the Main printed circuit board, and make some configuration selections to set up the relay output function.

There are six configuration selections that you must make or check to get the recorder to operate in accordance with your application needs.

- Relay 1 Action (N.O. / N.C.)
- Relay 1 Type
- Relay 1 Alarm/Control Setpoint
- Relay 2 Action (N.O. / N.C.)
- Relay 2 Type
- Relay 2 Alarm Setpoint

Relay configuration definitions

Table 3-1 defines selections associated with relay configuration parameters.

Table 3-1 Relay Configuration Parameters

Parameter	Selection	Definition
Relay Action	Normally Open	Refers to relay contacts being **OPEN** when the relay is de-energized.
	Normally Closed	Refers to relay contacts being **CLOSED** when the relay is de-energized.
Relay Type	A. ON-OFF Control (Direct)	Relay is **ENERGIZED** when the Process Variable (PV) is **ABOVE** the Setpoint (SP).
	B. ON-OFF Control (Reverse)	Relay is **ENERGIZED** when the PV falls **BELOW** the SP.
	C. High Alarm	Relay is **DE-ENERGIZED** when the PV is **ABOVE** the SP.
	D. Low Alarm	Relay is **DE-ENERGIZED** when the PV is **BELOW** the SP.
	E. High Limit Control*	Same as High Alarm, but remains **DE-ENERGIZED** until **MANUALLY** reset.
	D. Low Limit Control*	Same as Low Alarm, but remains **DE-ENERGIZED** until **MANUALLY** reset.

* These only operate with thermocouple and RTD inputs.

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Sample output function Table 3-2 lists selections for a sample output function.

Table 3-2 Selections for Sample Output Function

Item	Parameter	Second	Item	Parameter	Second
1	Relay #1 Action	Normally Open	4	Relay #2 Action	Normally Open
2	Relay #1 Type	Low Alarm	5	Relay #2 Type	High Alarm
3	Alarm/Control SP Relay #1	+1000	6	Alarm SP Relay #2	+1000

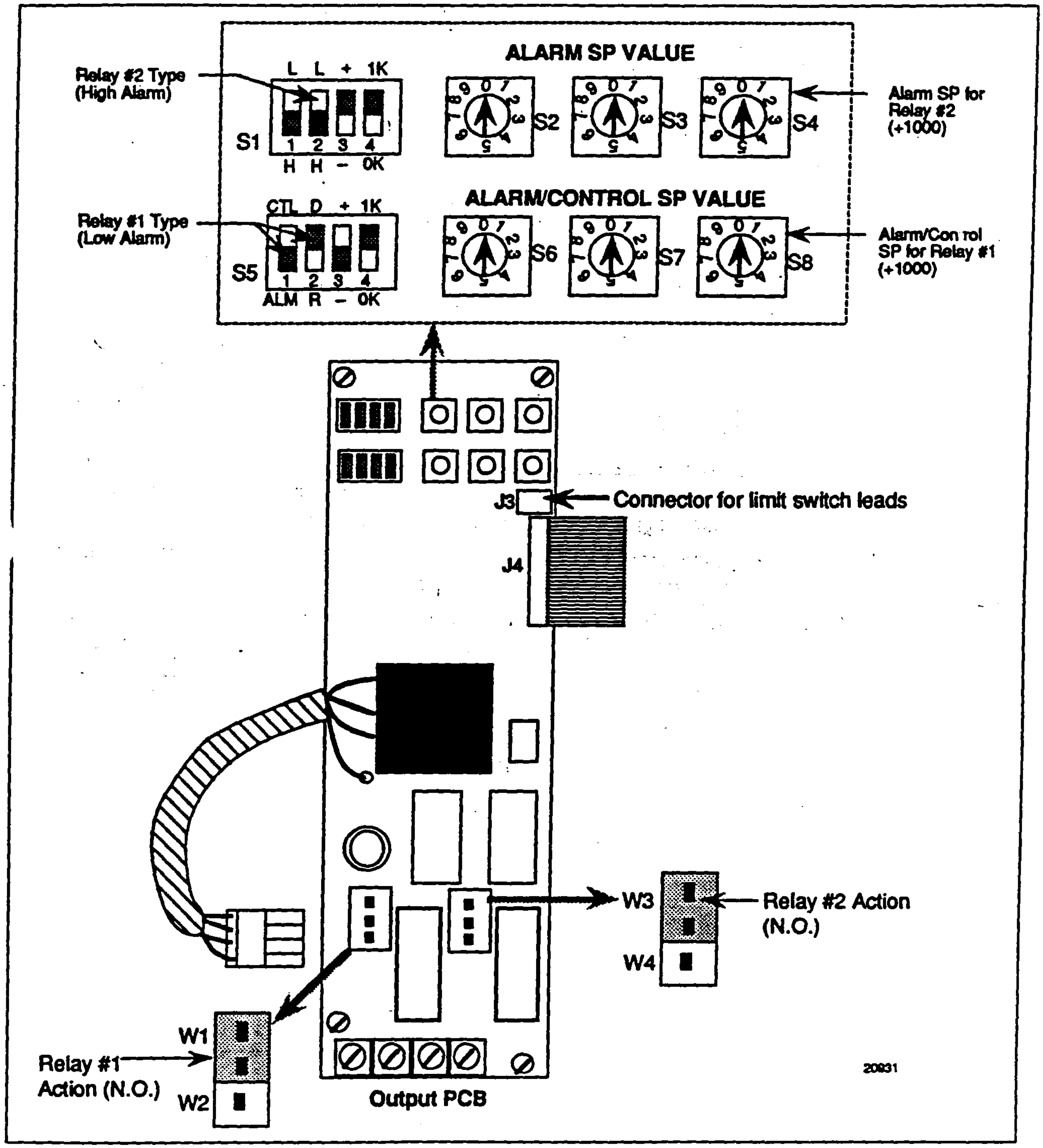
How to make selections This section provides a graphic summary of these configuration settings, and to assist you in the process of selection, it includes configuration worksheets on which you can note the configuration settings you require.

- Review the Sample Output functions in Table 3-2 and the Sample Worksheet (Figure 3-1). Refer to Figure 3-3 and mount the Relay Output board using the procedure in Table 3-3. Use the configuration graphics to understand how the sample worksheet was constructed.
- View the pertinent configuration selection illustrations for the Optional Relay Output board and mark the required settings on the Configuration Worksheet provided in the back of this section.
- Make the actual configuration settings on the Main printed circuit board in the recorder to match the worksheet.
- If you have a two-relay model, repeat the procedure to add and configure the Relay Output board for the Main printed circuit board for Pen #2.
- The recorder is now ready for operation with optional Relay Output.

3.3 Sample Configuration Worksheet for Relay Output

Sample Worksheet Figure 3-1 is a sample Configuration Worksheet for the Relay Output selections in Table 3-2.

Figure 3-1 Sample Configuration Worksheet for Output Selections in Table 3-2



3.4 Checking the Main Printed Circuit Board Pen Configuration

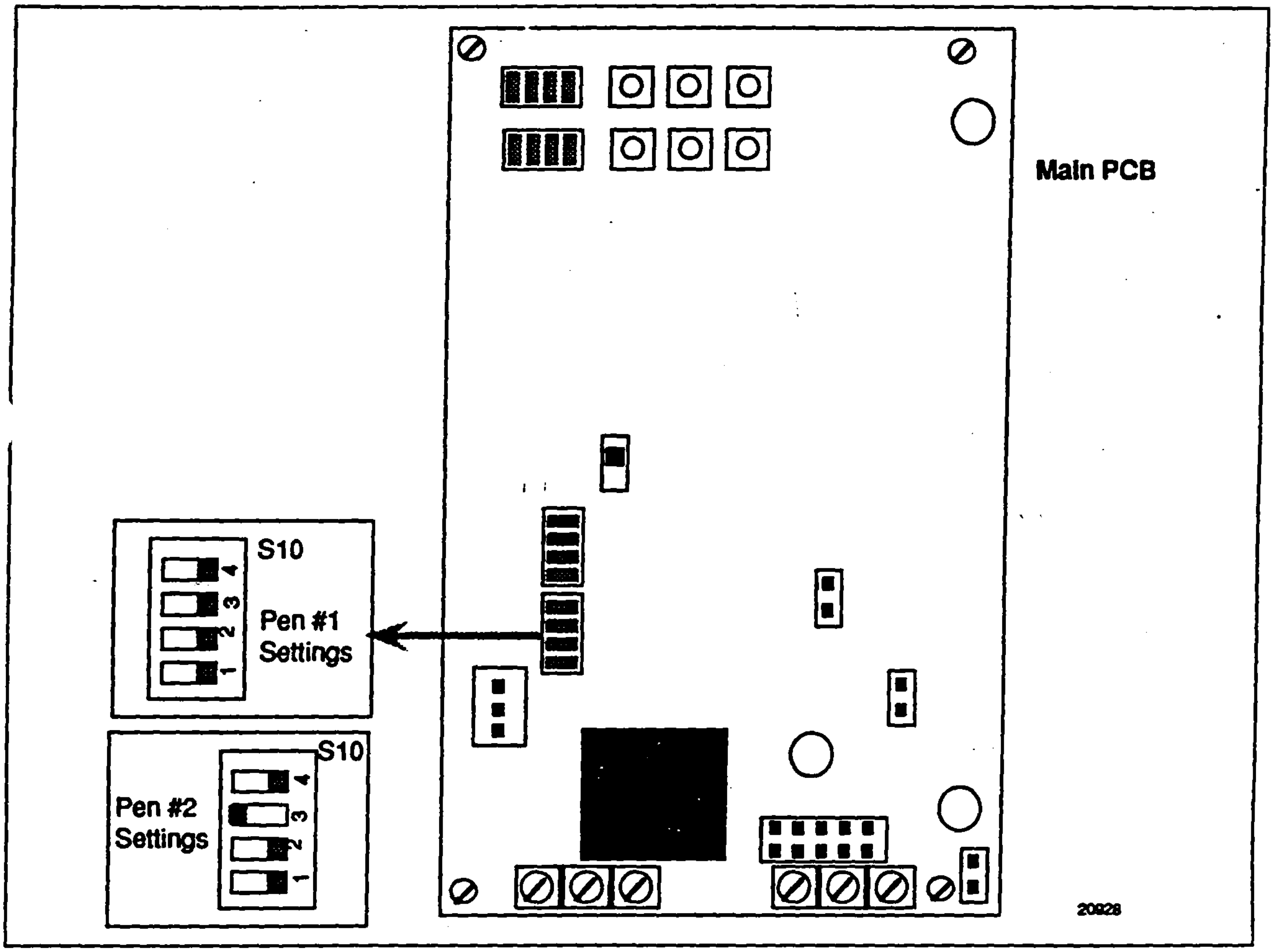
Introduction

Since the Main printed circuit board used for Pen #1 is identical to the one used for Pen #2, you must check the DIP switch S10, position 3, to be sure the Main PCB is configured to support the correct pen.

The Main printed circuit board for Pen #1 is always mounted on the right-hand side of the case, and the one for Pen #2 is always mounted on the left-hand side of the case. **The DIP switch is factory set for the correct pen.**

Refer to Figure 3-2 to check the Pen configuration.

Figure 3-2 Pen Configuration.



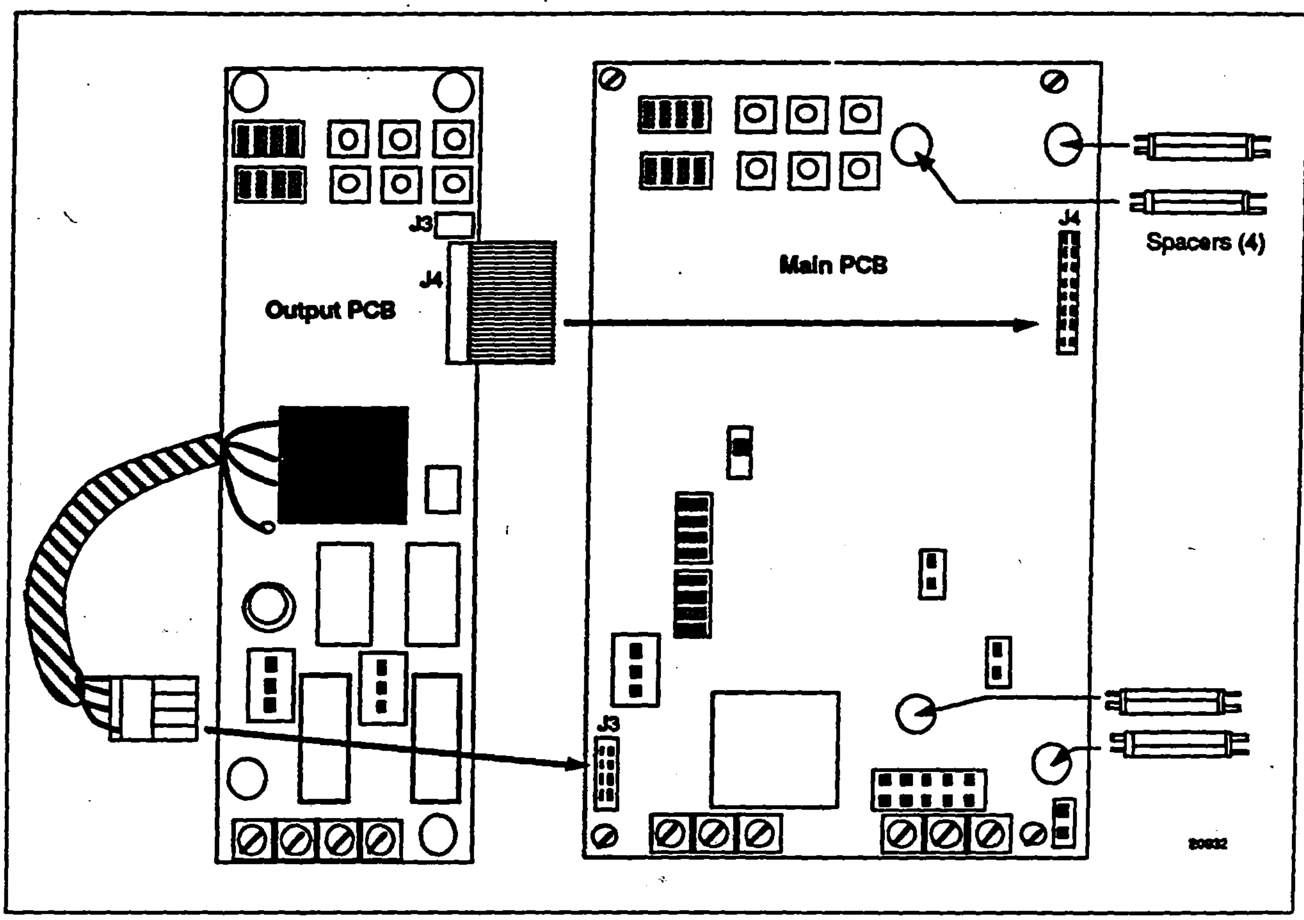
3.5 Mounting the Optional Relay Output Board

Introduction

If you ordered a recorder with relay output, you must mount the Relay Output printed circuit board on the Main printed circuit board. Refer to Figure 3-3 and follow the procedure in Table 3-3 to mount the board.

ATTENTION Be sure that you have set all the jumper positions on the Main printed circuit board before proceeding.
See *Section 2 - Recording Set Up.*

Figure 3-3 Mounting the Output Printed Circuit Board on the Main Printed Circuit Board



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Procedure

Follow the procedure in Table 3-3 to mount the Relay Output printed circuit board.

ATTENTION If Table 1 in the model number is 11, 22, or FF, repeat this procedure for the Main printed circuit board for Pen #2.

Table 3-3 Procedure for Mounting Relay Output Printed Circuit Board

Step	Action
1	Push the four plastic spacers (supplied with Output printed circuit board) into the holes on the right side of the Main printed circuit board for Pen #1 or Pen #2.
2	Hold the Output printed circuit board so that its mounting holes align with the spacers and plug the multi-pin connector from the Output printed circuit board into J4 connector on the Main printed circuit board. Be sure that the plug positions are aligned and matched with the pins on J4.
3	Push down on each corner of the Output printed circuit board in turn to seat the board on the spacers.
4	Plug the 4-pin connector from the transformer on the Output printed circuit board into the J3 connector on the Main printed circuit board.

3.6 Overview of Optional Relay Output Printed Circuit Board DIP Switch and Jumper Location

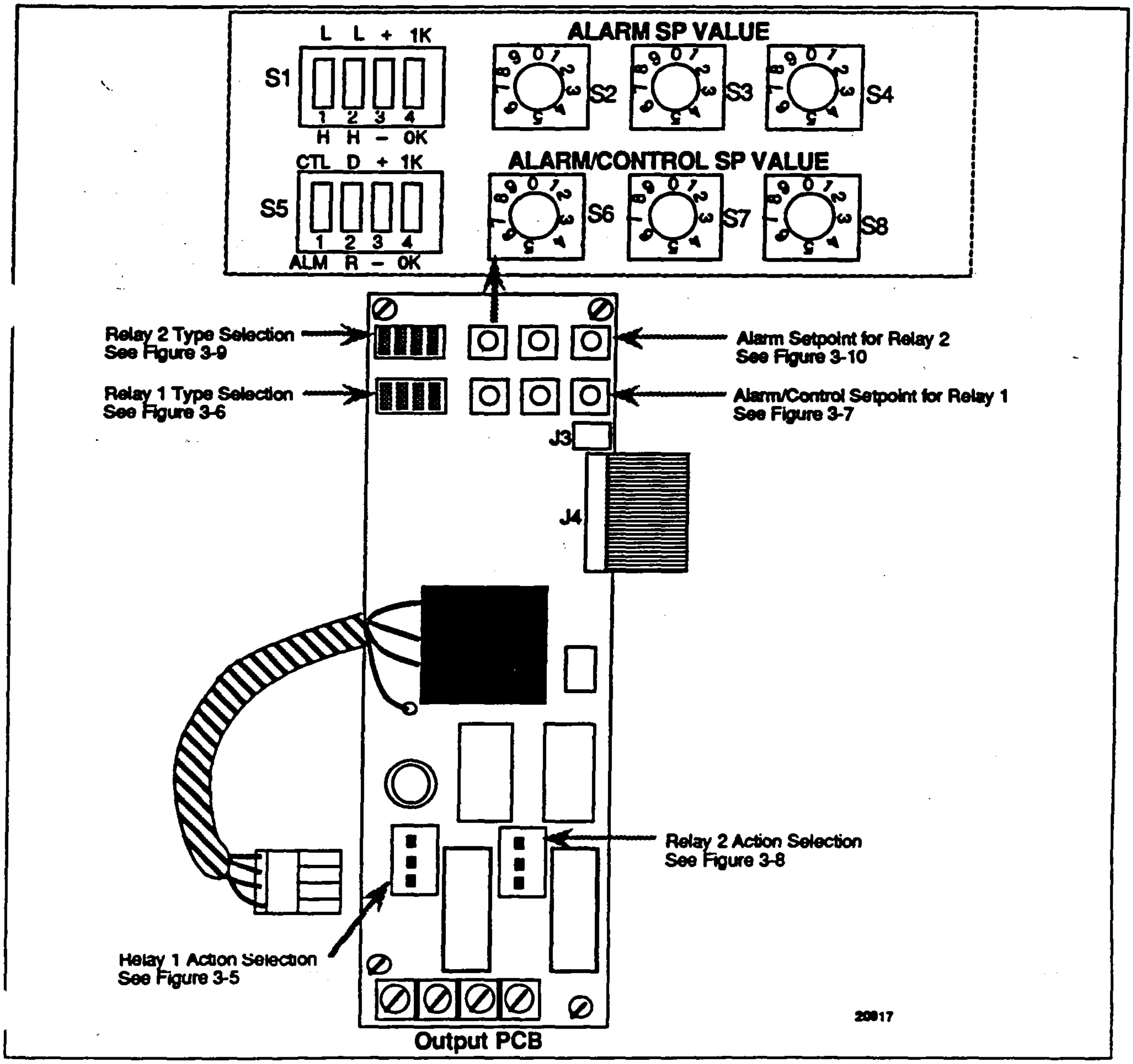
Introduction

Depending on the number of relays specified in Table I of the model number, you can configure the relay output function through the DIP switches on the Output PCB to be one of the following:

Output Function	Model Selection Table I =
Relay #1 is for ON/OFF Control & Relay #2 is for Alarm	20 or 22
Relays #1 and #2 are for Alarms	20 or 22
Relay #1 is for Alarm, ON/OFF Control, or Limit Control	10, 11, FO, or FF

Figure 3-4 is an overview of the DIP switch and jumper locations. Each location references a figure that contains the information you need to check or set the switches and jumpers.

Figure 3-4 Overview of Relay Output DIP Switch and Jumper Locations



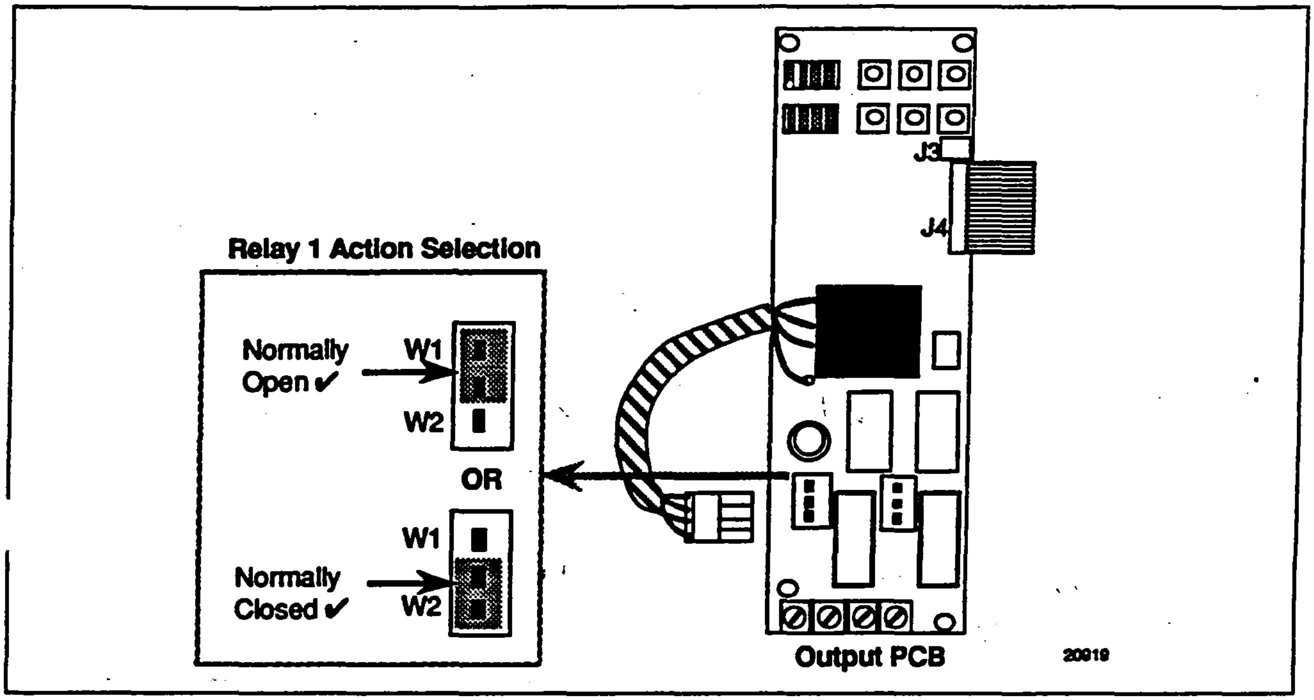
3.7 Selecting Relay #1 Action

Introduction

Figure 3-5 is a graphic view of the jumper locations for setting Relay #1 Action. Select the Output relay action as N.O. or N.C as shown in this figure. Note the selected action on the wiring label on the back of the chart plate for future reference.

This selection also applies for the Output PCB on the Main PCB for Pen #2, if Table I is 11, 22, or FF.

Figure 3-5 Jumper Locations for Relay #1 Action



3.8 Selecting Relay #1 Type

Introduction

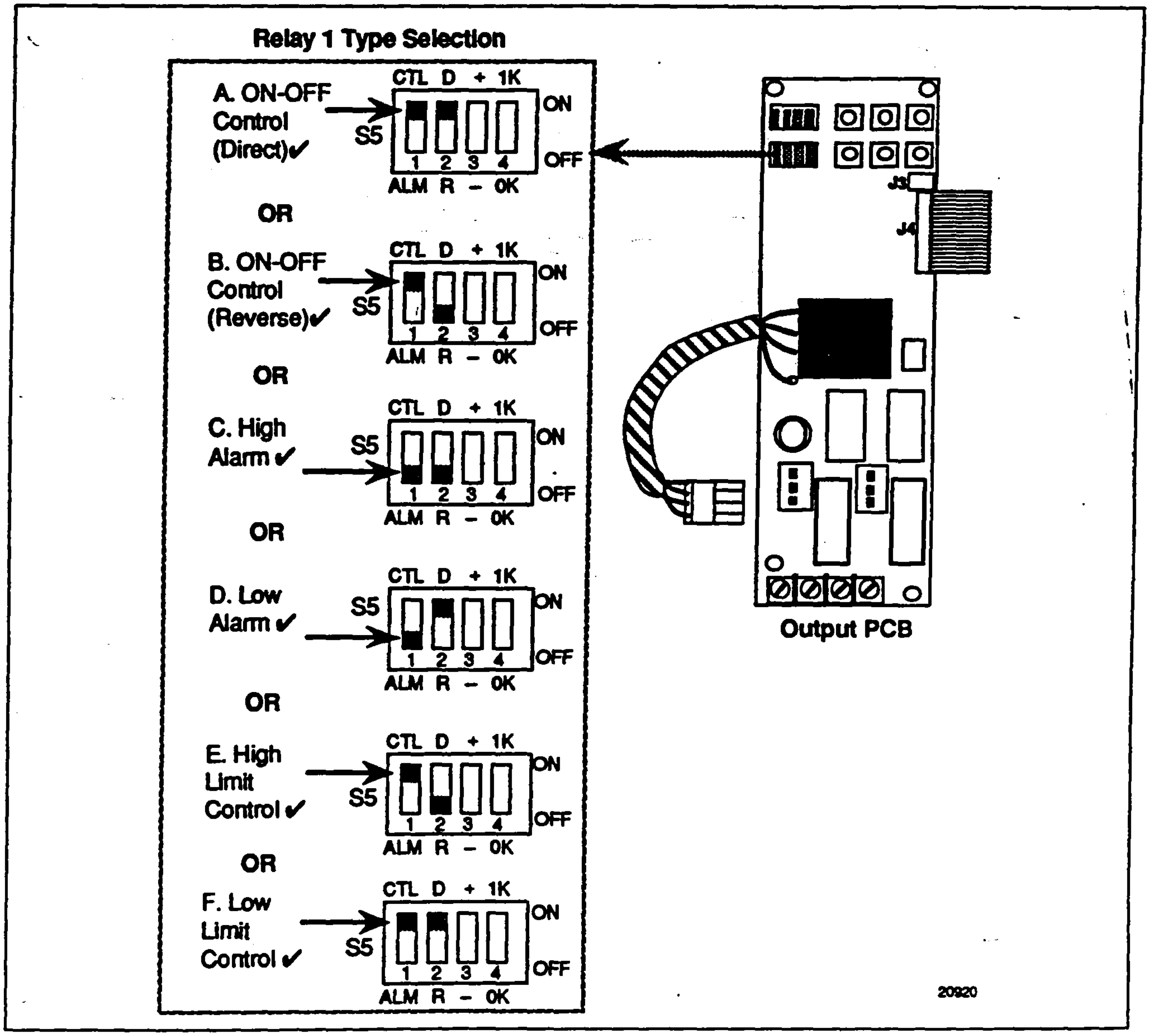
Figure 3-6 is a graphic view of the jumper locations for selecting Relay #1 Type. Set the DIP switches at location S5 as shown in this figure to select the desired Relay #1 Type. The selection can be one of the following:

- ON/OFF Control - Direct Action
- ON/OFF Control - Reverse Action
- High Alarm
- Low Alarm
- High Limit Control
- Low Limit Control

Note the selected action on the wiring label on the back of the chart plate for future reference.

ATTENTION If you select Limit Control refer to Figure 3-11 to install the manual reset switch required for Limit Control.

Figure 3-6 DIP Switch Settings for Relay #1 Type



3.9 Selecting Relay #1 Alarm/Control Setpoint

Introduction

You select the Relay #1 Setpoint for one of the Relay #1 types you have selected:

- Direct or Reverse acting ON/OFF control output
- High or Low Limit Control
- High or Low PV Alarm

Setpoint Value Limits

The setpoint value must be within the zero- and full-scale range for a given actuation type.
Be sure to use 0 - 100% scale values for linear inputs instead of actual measurement range values, and multiply the switch settings by 0.1 as for chart range values.

ON/OFF control

ON/OFF control operates on the sign of the error signal. Thus, for direct acting control, the output is ON whenever the PV is greater than the Setpoint; and for reverse acting control the output is ON whenever the PV is less than the Setpoint.

Hysteresis

Both the control and alarm actions have a fixed hysteresis of 1% of the chart range. This means that the output will turn ON at exactly the Setpoint value, but it won't turn OFF until the PV equals the SP minus the hysteresis value. Also, alarms will still turn ON when power is removed from the recorder.

Procedure

Figure 3-7 is a graphic view of the S5 DIP switch settings and rotary switch locations for Control/Alarm setpoints. Follow the procedure in Table 3-4 and make the settings as shown in this figure.

Table 3-4 Selecting Relay #1 Alarm/Control Setpoint

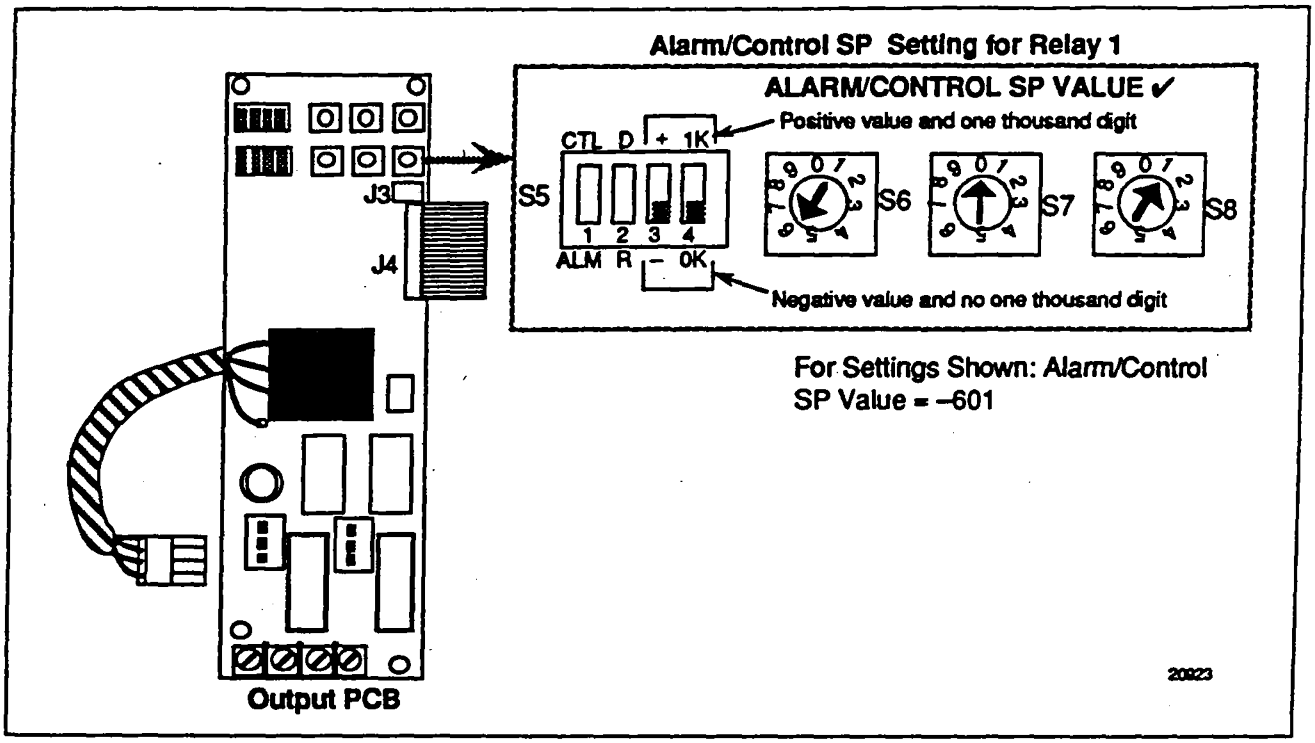
Step	Action
1	Locate DIP switch S5 in the upper left corner of the Output printed circuit board for Pen #1 or Pen #2.
2	Set position 3 to up/ON for a positive value, or down/OFF for a negative one.
3	Set position 4 to up/ON for one thousand digit, or down/OFF for a zero thousand digit.
4	Turn the arrow in the center of the rotary DIP switches S6, S7, and S8 to point to the desired number for 100, 10, and 1 digit places in Control or Alarm SP value for Relay #1.

Continued on next page

DIP switch and rotary switch locations

Figure 3-7 is a graphic view of the S5 DIP switch settings and rotary switch locations for Control/Alarm setpoints.

Figure 3-7 Relay #1 Control/Alarm Setpoints DIP Switch Settings



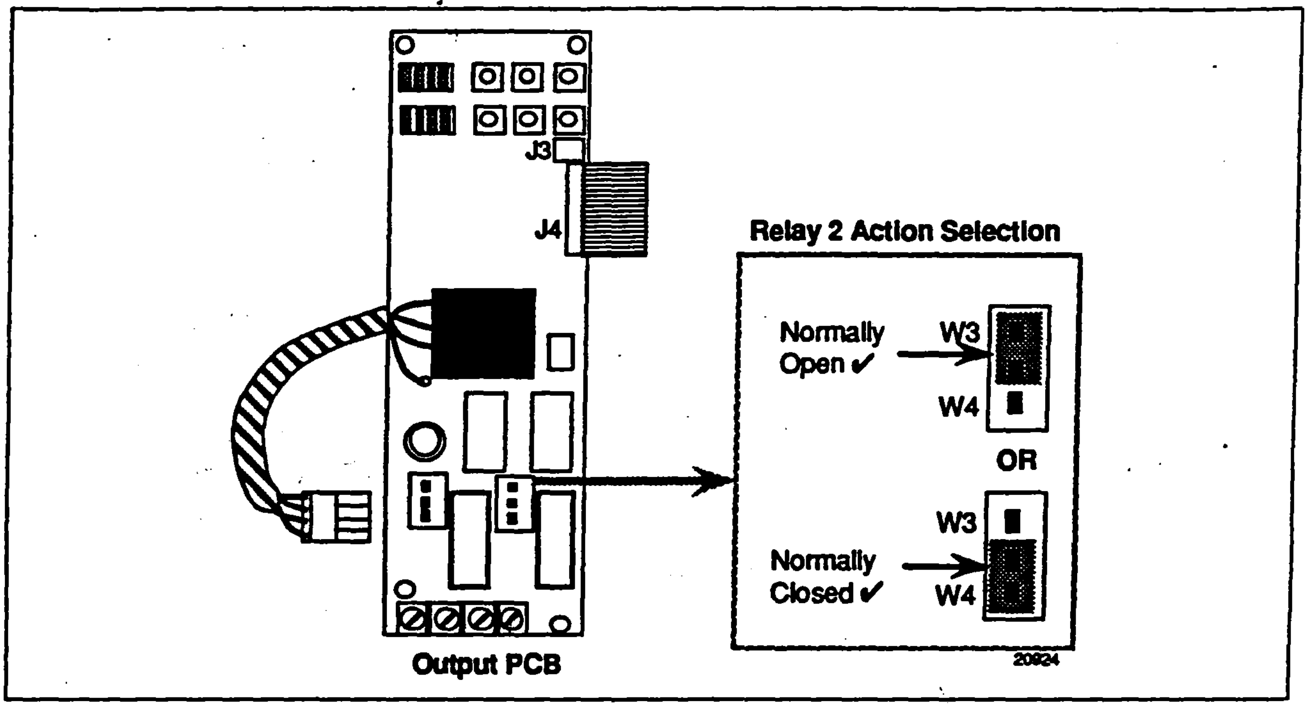
3.10 Selecting Relay #2 Action

Introduction

Figure 3-8 is a graphic view of the jumper locations for setting Relay #2 Action (Model Table 1 is 20 or 22 only). Select the Output relay action as N.O. or N.C as shown in this figure. Note the selected action on the wiring label on the back of the chart plate for future reference.

- This selection also applies for the Output printed circuit board on the Main printed circuit board for Pen #2, if Model Table I is 22.

Figure 3-8 Jumper Locations for Relay #2 Action



3.11 Selecting Relay #2 Type

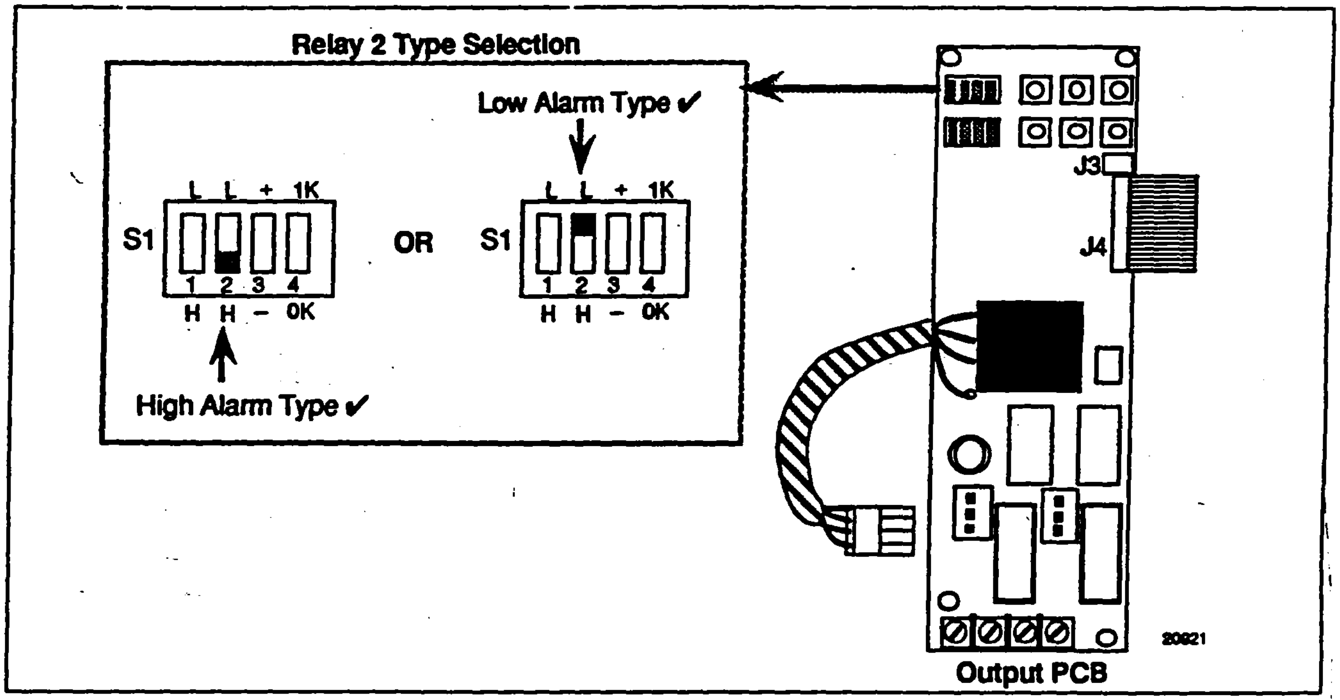
Introduction

Figure 3-9 is a graphic view of the jumper locations for selecting Relay #2 Type. Set the DIP switches at location S1 as shown in this figure to select the desired Relay #2 Type. The selection can be one of the following:

- High Alarm Type
- Low Alarm Type

Note the selected action on the wiring label on the back of the chart plate for future reference.

Figure 3-9 DIP Switch Settings for Relay #2 Type



3.12 Selecting Relay #2 Alarm Setpoint

Introduction

You select the Relay #2 Alarm Setpoint for one of the Relay #2 types you have selected:

- High Alarm Type
- Low Alarm Type

Hysteresis

Both the control and alarm actions have a fixed hystersis of 1% of the chart range. This means that the output will turn ON at exactly the Setpoint value, but won't turn OFF until the PV equals the SP minus the hystersis value. Also, alarms will still turn ON when power is removed from the recorder.

"No" alarm condition

A "NO" alarm condition energies the alarm relay. Thus, if you want the relay to de-energize on an alarm condition, be sure to use the W4 jumper (refer to Figure 3-8).

Procedure

Figure 3-10 is a graphic view of the S1 DIP switch settings and rotary switch locations for Alarm setpoints. Follow the procedure in Table 3-5 and make the settings as shown in this figure.

Table 3-5 Selecting Relay #2 Alarm Setpoint

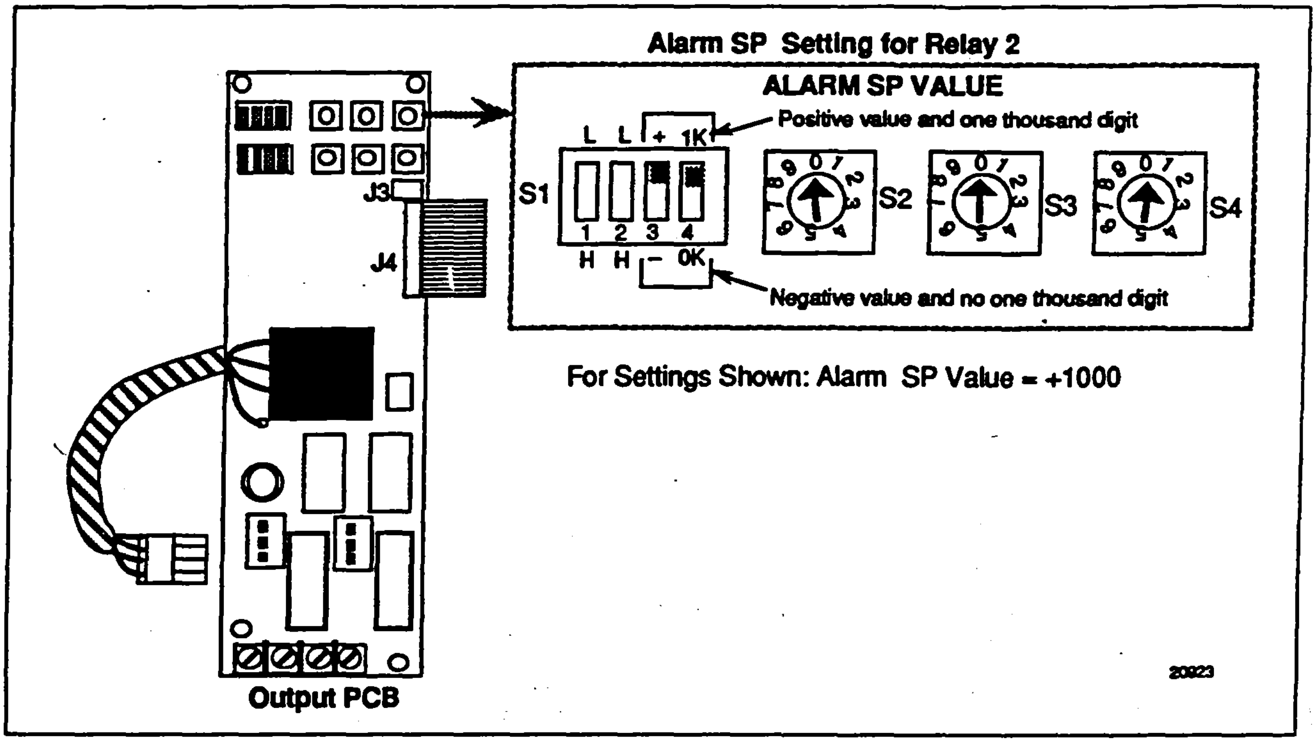
Step	Action
1	Locate DIP switch S1 in the upper left corner of the Output printed circuit board for Pen #1 or Pen #2.
2	Set position 3 to up/ON for a positive value, or down/OFF for a negative one.
3	Set position 4 to up/ON for one thousand digit, or down /OFF for a zero thousand digit.
4	Turn the arrow in the center of the rotary DIP switches S2, S3, and S4 to point to the desired number for 100, 10, and 1 digit places in Alarm SP value for Relay #2.

Continued on next page

DIP switch and rotary switch locations

Figure 3-10 is a graphic view of the S1 DIP switch settings and rotary switch locations for Alarm setpoints.

Figure 3-10 Relay #2 Alarm Setpoints DIP Switch Settings



3.13 Installing a Manual Reset Switch for Limit Control

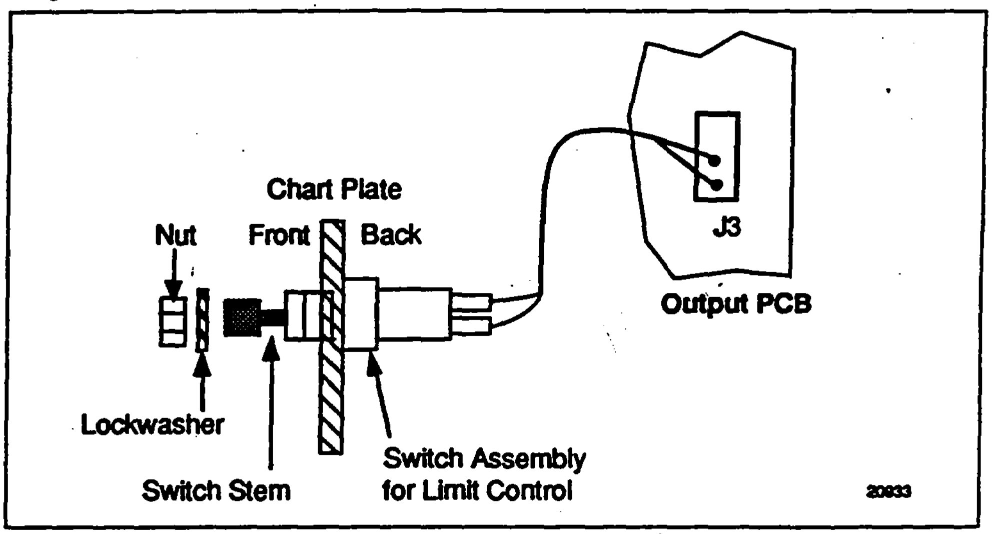
Introduction

If you have Limit Control, you must install the manual reset switch assembly supplied with the Output printed circuit board. Refer to Figure 3-11 and follow the procedure in Table 3-6.

Table 3-6 Installing the Manual Reset Switch

Step	Action
1	Route the 2-wire cable along side other cables from the Main printed circuit board to the back of the chart plate and secure it with cable ties or tape.
2	Remove the nut and lockwasher from the pushbutton switch stem. From the back of the chart plate, insert the switch stem into one of the 1/4" (6.4mm) holes in the upper left corner of the chart plate and secure the switch with the nut and lockwasher from the front of the chart plate.

Figure 3-11 Installing the Manual Reset Switch

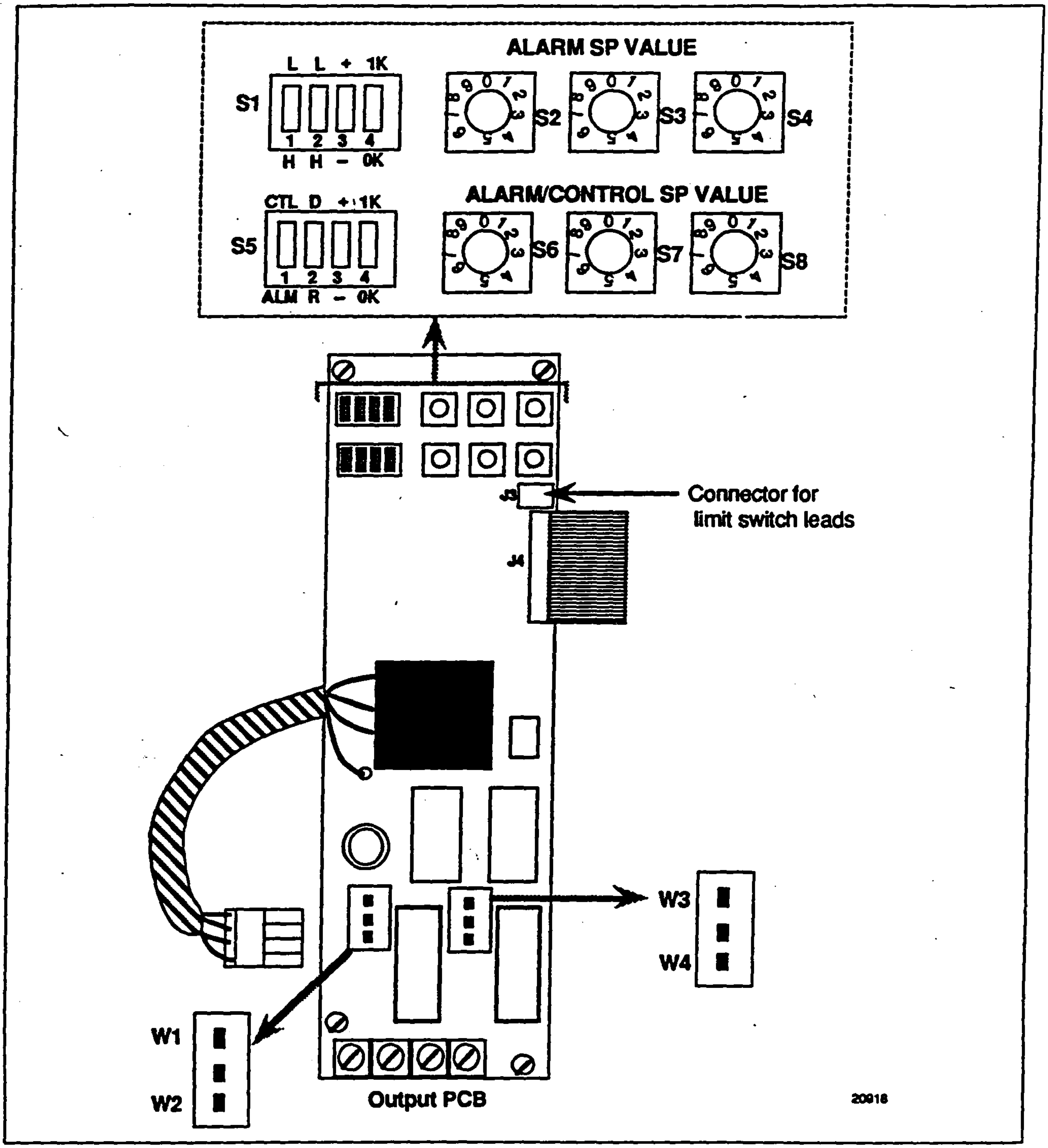


ATTENTION

- Refer to Figure 3-12 for a Configuration Worksheet for Relay Output #1.
- Refer to Figure 3-13 for a Configuration Worksheet for Relay Output #2.

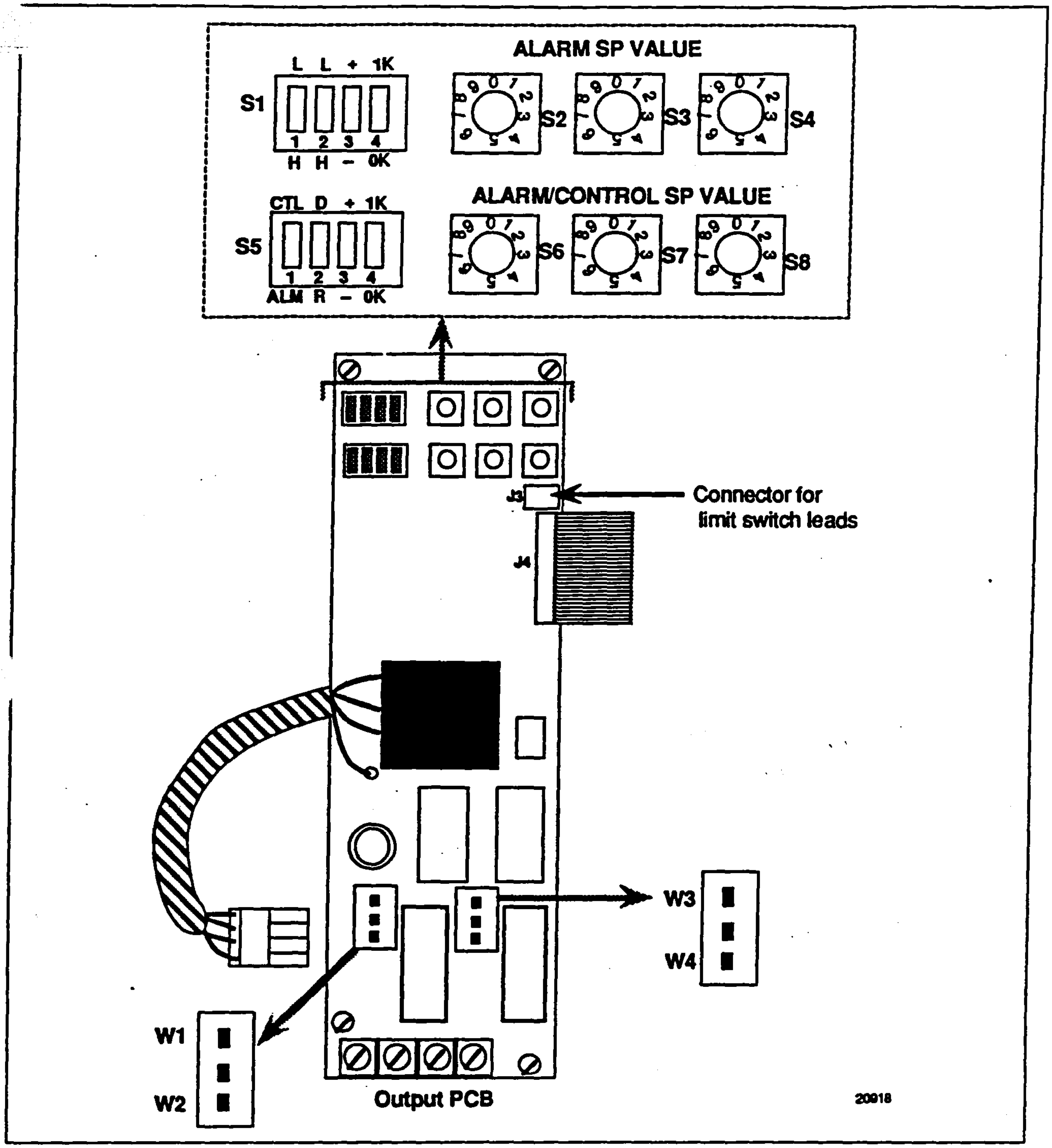
3.14 Configuration Worksheet for Relay Output #1

Figure 3-12 Configuration Worksheet for Relay Output #1



3.15 Configuration Worksheet for Relay Output #2

Figure 3-13 Configuration Worksheet for Relay Output #2



Section 4 – Installation

4.1 Overview

Introduction

Installation of the DR4200 Model GP Recorder consists of mounting and wiring the recorder according to the instructions given in this section.

Read the pre-installation information, check the model number interpretation in Section 1, and become familiar with your model selections, then proceed with installation.

What's in this section?

This section contains the following information:

Pre-installation Information

If the recorder has not been removed from its shipping carton, inspect the carton for damage and remove the recorder. Inspect the unit for any obvious shipping damage and report any damage due to transit to the carrier.

• Make sure a bag containing mounting hardware is included in the carton with the recorder.

• Check that the model number shown on the chart plate agrees with what you have ordered.

Continued on next page

Operating limits

We recommend that you review and adhere to the operating limits listed in Table 4-1 when you install your recorder.

Table 4-1 Operating Limits and Condensed Specifications

Condition	Specifications
Accuracy	See Appendix C
Ambient Temperature	32 to 131°F (0 to 55°C)
Relative Humidity	5 to 90% RH at 40°C (104°F)
Vibration Frequency Acceleration	 0 to 200Hz 0.5g
Mechanical Shock Acceleration Duration	 5g 30ms
Mounting Position from Vertical Tilted Forward Tilted Backward Tilted to side(±)	 5° 90° 20°
Power Voltage(VRMS) Frequency(Hz)	 102 to 132 Vac 204 to 264 Vac 49 to 51 Hz 59 to 61 Hz
Power Consumption	9 Watts Maximum
Type of Actuations	*Thermocouple:* J, K, or T *RTD:* Platinum 100 Ohms* *Linear:* 4–20mAdc, 0–20mAdc,0–50mVdc, 0–5Vdc, 1–5Vdc * IEC Alpha = 0.00385
Minimum Input Span	Range is fully configurable within span limitation of the sensing element.
Input Impedance	*0-20 mA dc, 4-20 mA dc:* 250 ohms *0-5 and 1-5 Vdc:* 200K ohms *RTD:* 13.3K ohms *All others:* 10 Megohms
Span Step Response Time	7 seconds maximum
Reproducibility	0.1 percent of span
Sampling Rate	Input sampled 2 times every 1.3 seconds
Input Filter	Analog with time constant of 3 seconds and digital with time constant of 1 second

Continued on next page

Operating limits, continued

Table 4-1 Operating Limits and Condensed Specifications, continued

Condition	Specifications
Case	Molded, foamed-Noryl* with gasketed door to meet NEMA 3 enclosure requirements.
Pen	Disposable fiber-tip ink cartridge, line length per cartridge more than 1000ft (305m) *One Pen:* Purple *Two Pen:* Purple (pen one) and red (Pen two)
Chart	10.34-inch (260 mm) diameter chart with standard preprinted markings and a calibrated width of 4 inches (100 mm).
Wiring Connections	0.1 percent of span
Color	*Case:* Black *Door (standard):* Caribbean blue or gray
Weight	12 lbs (5.4 kg)
Mounting	Panel or surface mounted
Options	
Relay Ouput	Two SPST relays *Relay Contact Ratings:* Resistive Load: 5A @ 120 Vac or 2.5A @ 240 Vac. Inductive Load: 50 VA @ 120 Vac or 240 Vac.
Approval Bodies	UL, CSA, FM (Limit Control)

4.2 Mounting Considerations and Overall Dimensions

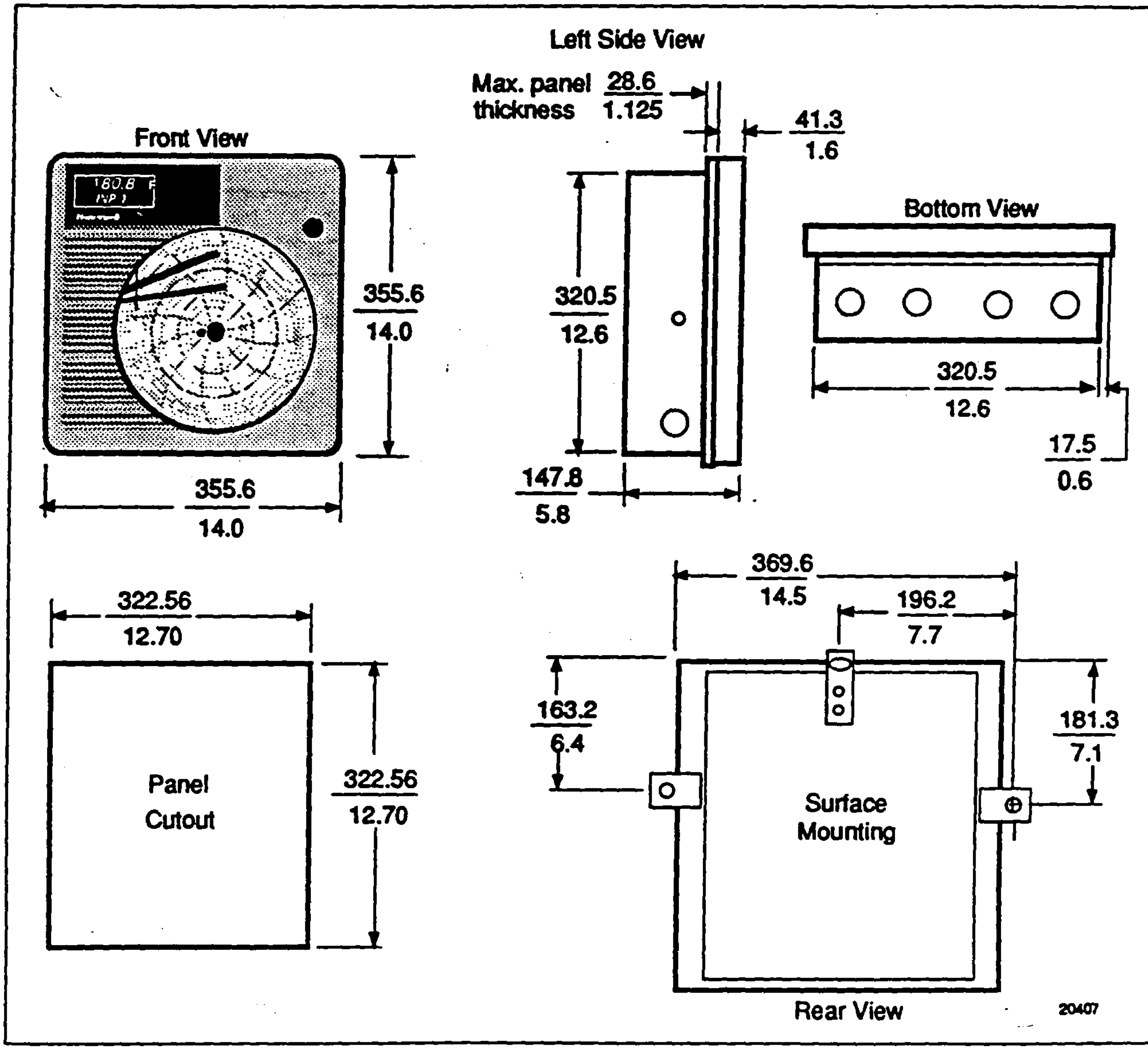
Physical considerations The recorder can be mounted flush in a panel or on the surface of a panel or wall using the mounting kit supplied with the recorder. Adequate access space must be available at the back of the panel for installation and servicing activities.

• The overall dimensions and panel cutout requirements for mounting the recorder are shown in Figure 4-1.

• The recorder's mounting enclosure must be grounded according to CSA standard C22.2 No. 0.4 or Factory Mutual Class No. 3820 paragraph 6.1.5.

Overall dimensions Figure 4-1 shows the overall dimensions for mounting the recorder.

Figure 4-1 Overall Dimensions



4.3 Mounting Methods

Introduction

There are two methods available for mounting your recorder. They are:

- Flush in Panel (New Panel Cutout)
- On Surface (of Panel or Wall)

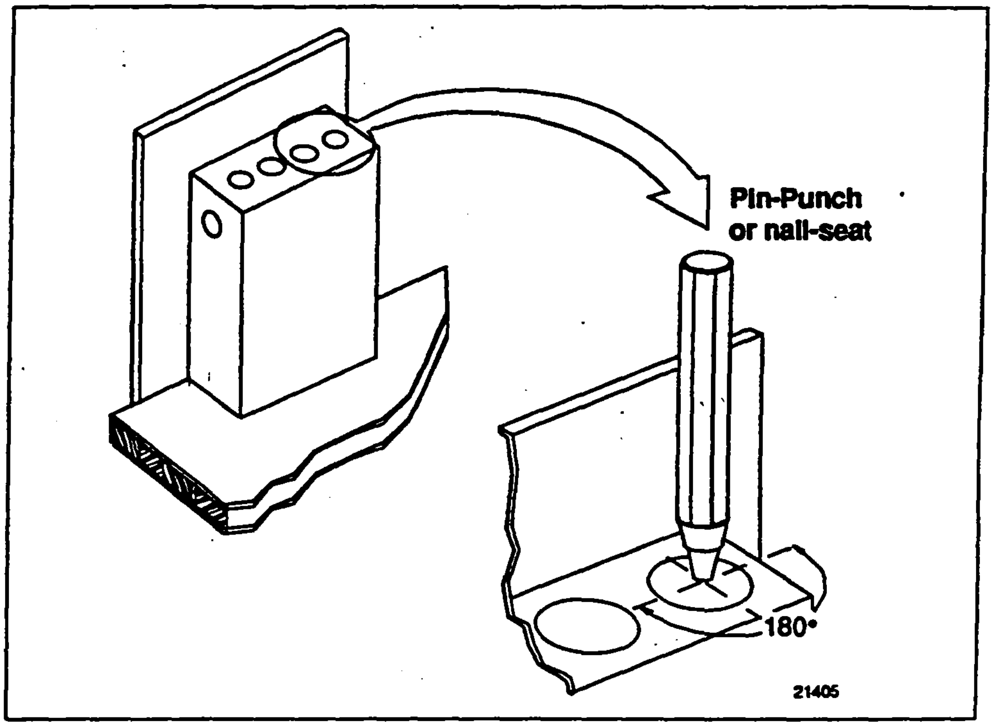
Procedures for each method follow. Choose the one that meets your mounting requirements. Use the associated dimension drawings for reference.

How to remove knockouts for conduits

Before you mount the recorder, remove the appropriate "knockouts" in the bottom and/or sides of the recorder case for wire entry via 1/2" (12.7mm) conduits. Refer to Figure 4-2 for knockout locations.

ATTENTION The knockouts are really plugs that you just have to push out to remove.

Figure 4-2 How to Remove Knockouts



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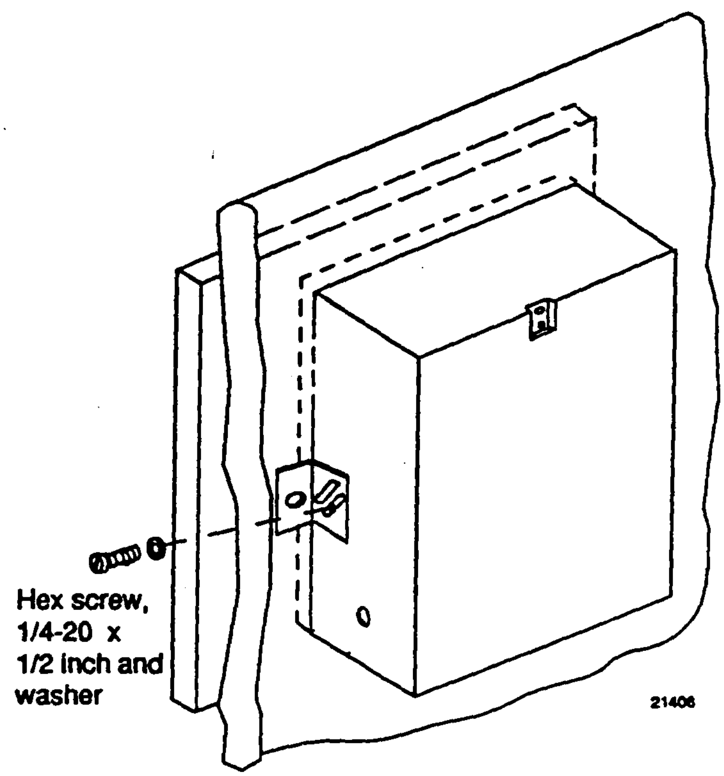
Mounting flush in panel (New panel cutout)

Refer to Figure 4-3 and follow the procedure in Table 4-2 to make a new cutout in a panel and mount your recorder in the cutout.

Table 4-2 Mounting Flush in a New Panel Cutout

Step	Action
1	At the appropriate location, make a square cutout in the panel measuring 12.7 ±0.060 inches by 12.7 ±0.060 inches (322.58 ±1.52 by 322.58 ±1.52 millimeters). See Figure 4-3.
2	Orient the recorder case properly and slide it into the cutout from the front of the panel. Support the recorder as shown in steps 3 and 4.
3	Refer to Figure 4-3. From the back of the panel, attach a mounting bracket to each side of the recorder case using a 1/4-20 x 1/2 inch hex screw for each bracket (mounting hardware supplied with recorder). Leave the screws slightly loose so you can adjust the brackets.
4	While holding the recorder firmly against the panel, slide each bracket against the back of the panel and tighten the screws.

Figure 4-3 Mounting Flush in a New Panel Cutout



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Mounting on surface (of panel or wall)

Refer to Figure 4-4 and follow the procedure in Table 4-3 to mount your recorder on a surface (Panel or Wall).

ATTENTION Three (3) screws must be supplied by the user for attaching the mounting hardware (brackets and support hook) to panel or wall.

Table 4-3 Mounting Flush on a Surface (of Panel or Wall)

Step	Action
1	Using two flat-head 10-32 x 1/4-inch screws supplied with the recorder, fasten the support hook into the recess at the back of the recorder case as shown in Figure 4-4.
2	Using 1/4-20 x 1/2-inch hex screws and lockwashers, attach a mounting bracket to each side of the case. Leave the screws slightly loose so as to permit some adjustments of the brackets.
3	On the panel, mark the locations for the three holes, as shown by the hole pattern in Figure 4-4.
4	Using a drill of appropriate size for user-supplied screws, drill a hole in the front of the panel for the eye of the support hook.
5	Insert the screws for the support hook into the panel, allowing the screw head to protrude approximately 5/16-inch.
6	Hang the recorder support hook on the screw. Make sure that the locations for the other two holes (marked in step three) are correct. If not, make sure that the recorder is aligned vertically, and use the brackets as templates to mark the proper locations.
7	Remove the recorder from the panel and drill the other two holes.
8	Hang the recorder on the screw by the support hook and insert the other two user-supplied screws through the brackets into the panel. Tighten the two hex screws that attach the brackets to the case.

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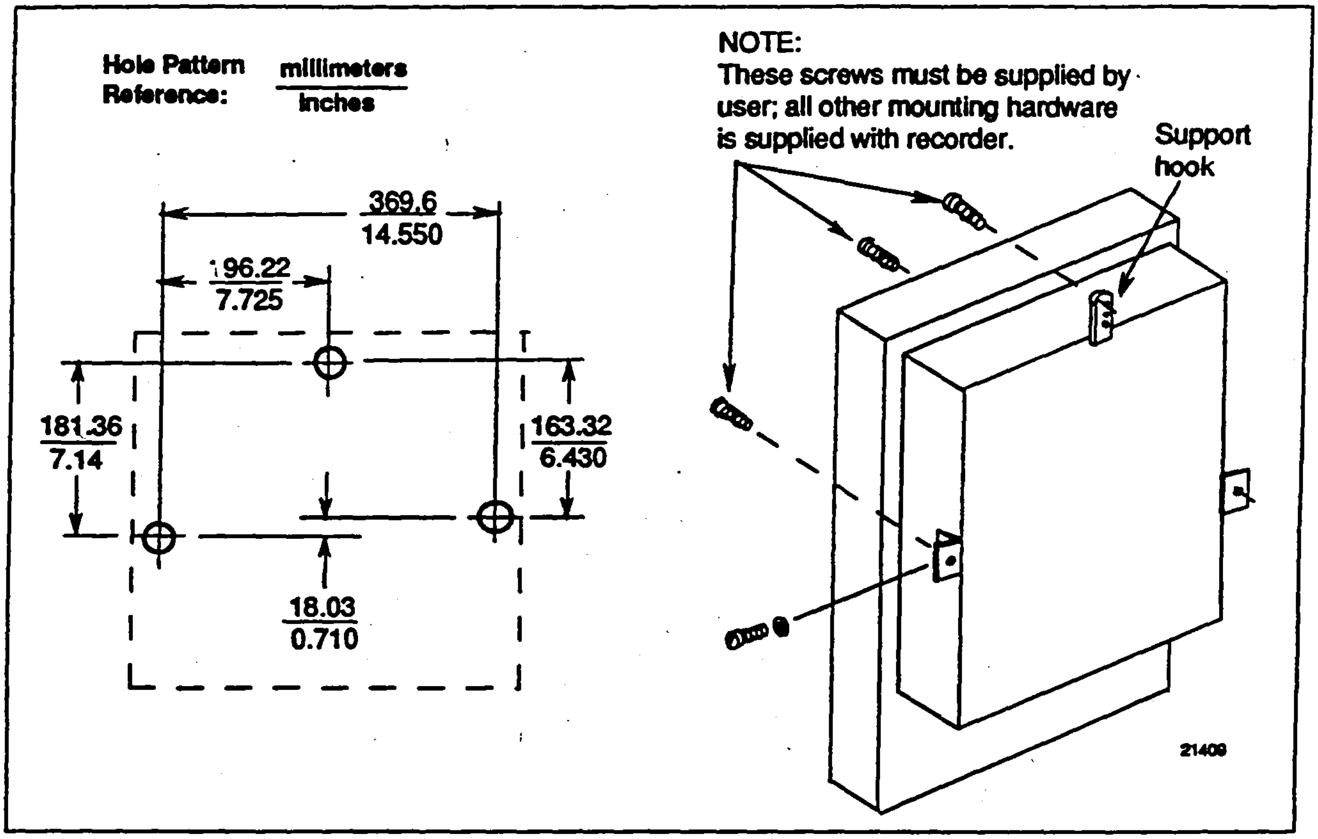
Mounting on surface (of panel or wall), continued

Figure 4-4 Mounting Flush on a Surface (of Panel or Wall)



4.4 Wiring Prerequisites

Taking electrical noise precautions

Electrical noise is composed of unabated electrical signals which produce undesirable effects in measurements and control circuits.

Digital equipment is especially sensitive to the effects of electrical noise. Your recorder has built-in circuits to reduce the effect of electrical noise from various sources. If there is a need to further reduce these effects:

- **Separate External Wiring** - separate connecting wires into bundles (see Table 4-4) and route the individual bundles through separate conduits or metal trays.
- **Use Suppression Devices** - for additional noise protection, you may want to add suppression devices at the external source. Appropriate suppression devices are commercially available.

NOTE For additional noise information, refer to *Appendix B*.

Permissible wire bundling

Table 4-4 shows which wire functions should be bundled together.

Table 4-4 Permissible Wiring Bundling

Bundle No.	Wire Functions
1	• Line power wiring • Earth ground wiring • Control relay output wiring • Line voltage alarm wiring
2	Analog signal wire, such as: • Input signal wire (thermocouple, 4 to 20 mA, etc.) • 4-20mA output signal wiring • Slidewire feedback circuit wiring • Digital input signals • Communications
3	• Low voltage alarm relay output wiring • Low voltage wiring to solid state type control circuits

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4.4 Wiring Prerequisites, Continued

Identify your wiring requirements

To determine the appropriate diagrams for wiring your recorder, refer to the model number interpretation in *Section 1 - Overview*. The model number of the recorder can be found on the chart plate.

Wiring the recorder

Using the information contained in the model number, select the appropriate wiring diagrams from the figures listed below and wire the recorder accordingly.

Wiring Requirements	Figure
AC Line Power	4-5
Input 1	4-6
Input 2	4-7
Relay Output (1 or 2 pen)	4-8
Relay Output (2 pens)	4-9

4.5 Input Wiring Procedures

AC Line Power

Refer to Figure 4-5 and follow the procedure in Table 4-5 to connect the AC line power.

WARNING **Be sure that the line voltage is OFF before connecting the power wires to the recorder.**

Table 4-5 AC Line Power Wiring

Step	Action
1	Open the recorder door. Loosen the captive screw in the chart plate and swing the plate out.
2	Locate terminal block TB1 on the bottom left edge of the Main printed circuit board for pen 1 (refer to Figure 4-5).
3	Run the power wires separately through second conduit from the right on the bottom of the case.
4	Strip 3/4-inch maximum of insulation from the end of each wire and form end to fit under a screw connection.
CAUTION **To avoid damaging the recorder, be sure that you install the power wires into the correct screw terminals.** **Be sure you have positioned Jumper W1 (See Section 2 - Set Up) to match the given supply voltage rating - 120 or 240 Volts for both pen 1 and pen 2 Main printed circuit boards. The factory setting is 120 Volts.**	
5	Insert the *green* wire (G) under the first screw from the right, the *white* wire (N/L2) under the second screw from the right, and the *black* wire (L/L1) under the third screw from the right. Tighten the screws to secure the wires. ATTENTION On recorders with two pens, an internal cable channels power to TB1 on the main printed circuit board for pen 2 from TB1 on the main printed circuit board for pen 1.
6	Dress the wires as slack as possible. This keeps the noise signal on these wires from bypassing built-in suppression. Also, do not bundle any low level signal wires with the power wires. Refer to Table 4-4 for permissible wire bundling. Refer to Appendix B for additional information concerning noise interference prevention.
WARNING **Input line voltage will be present on the instrument ground plane if safety ground is not attached.**	

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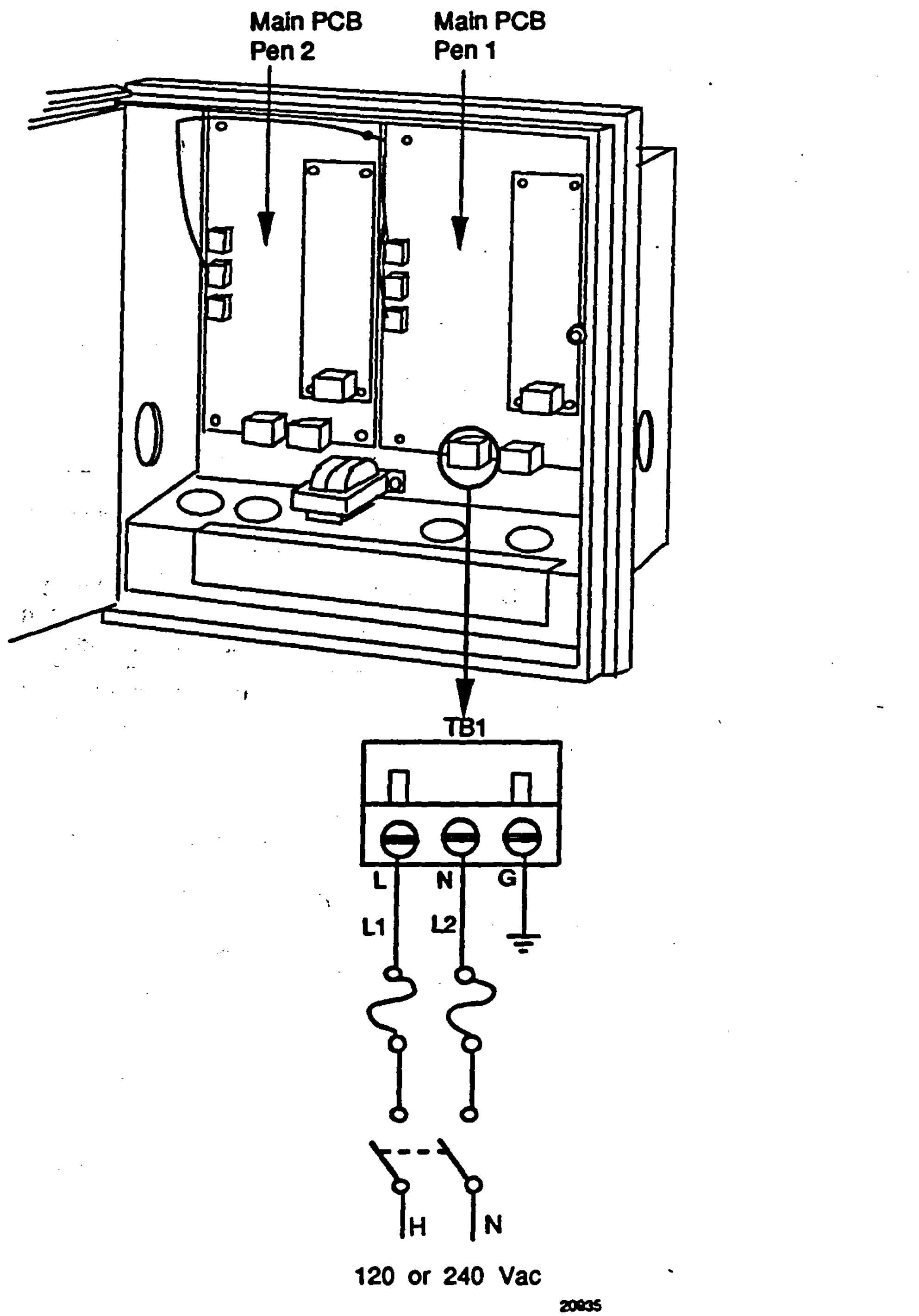
.C line power, continued

Figure 4-5 AC Line Power Wiring



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nput 1

You can wire Input 1 for Thermocouple, RTD, mA, mV, or Volt actuations.

Refer to Figure 4-6 and follow the procedure in Table 4-6 to wire the input.

ATTENTION Make sure you have configured the recorder to accept the desired input type. Refer to *Section 2 - Recording Set Up*.

Table 4-6 Input 1 Wiring

Step	Action
1	Open the recorder door. Loosen the captive screw in the chart plate and swing the plate out.
2	Locate terminal block TB2 on the bottom right edge of the Main printed circuit board for pen 1 (refer to Figure 4-6).
CAUTION Remove the factory installed jumper across the (–) and (R) terminals on TB2 before making input connections.	
3	Run the input wires through the desired conduit - DO NOT bundle them with the power wires.
4	Strip 3/4-inch maximum of insulation from the end of each wire and form end to fit under a screw connection.
5	Insert the wires under the appropriate screws for the applicable input type. See Figure 4-6 for specific input actuation wiring. Tighten the screws to secure the wires.

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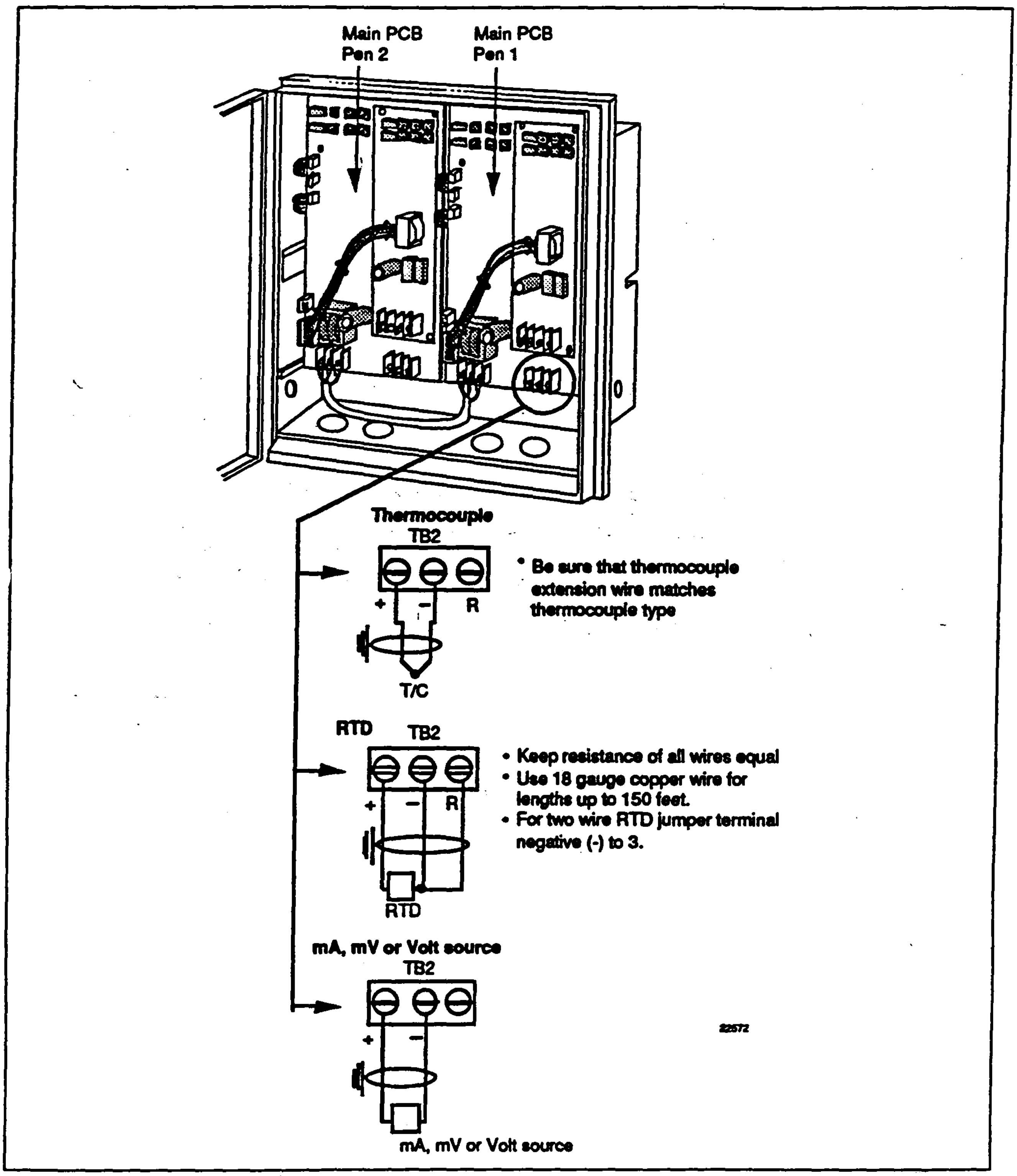
Input 1, continued

Figure 4-6 Input 1 Wiring



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Input 2

You can wire Input 2 for Thermocouple, RTD, mA, mV, or Volt actuations.

Refer to Figure 4-7 and follow the procedure in Table 4-7 to wire the input.

ATTENTION Make sure you have configured the recorder to accept the desired input type (refer to *Section 2 - Recording Set Up*).

Table 4-7 Input 2 Wiring

Step	Action
1	Open the recorder door. Loosen the captive screw in the chart plate and swing the plate out.
2	Locate terminal block TB2 on the bottom right edge of the main printed circuit board for pen 2 (refer to Figure 4-7).
CAUTION Remove the factory installed jumper across the (–) and (R) terminals on TB2 before making input connections.	
3	Run the input wires through the desired conduit - DO NOT bundle them with the power wires.
4	Strip 3/4-inch maximum of insulation from the end of each wire and form end to fit under a screw connection.
5	Insert the wires under the appropriate screws for the applicable input type. See Figure 4-7 for specific input actuation wiring. Tighten the screws to secure the wires.

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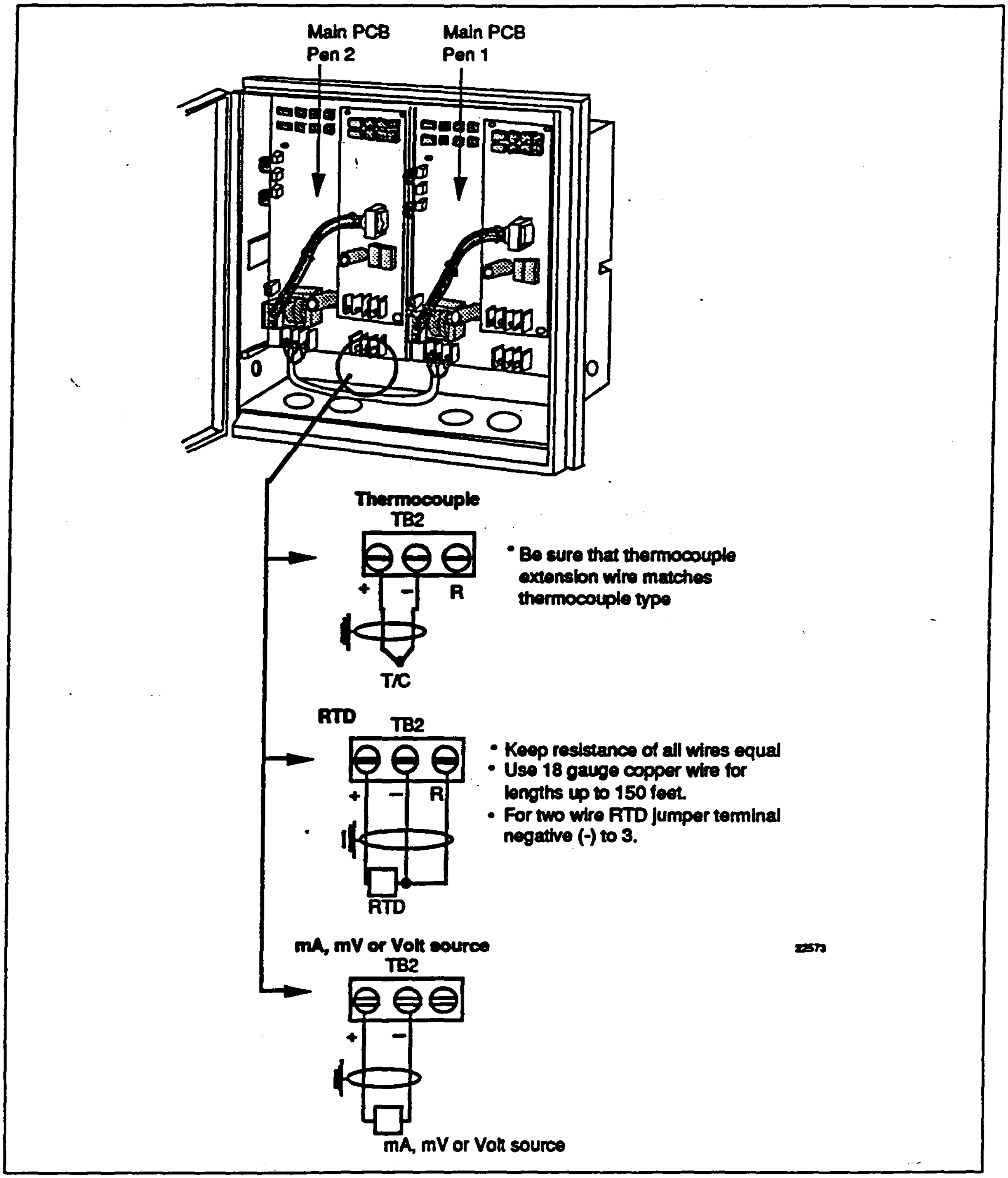
Input 2, continued

Figure 4-7 Input 2 Wiring



4.6 Output Wiring Procedures

elay output wiring (1 or 2 Pen Models)

You can wire the Relay Output as follows:

For 1 Relay - Pen 1 or Pen 2 (Model Number Table 1 = 10, 20, F0),

or

For 2 Relays - Pen 1 or Pen 2 (Model Number Table 1 = 11, 22, FF, 2F)

ATTENTION

Make sure you have configured the recorder to provide the desired control/alarm function and action, as applicable.
Refer to *Section 2 - Set Up.*

Refer to Figure 4-8 and follow the procedure in Table 4-8 to wire the Relay Outputs.

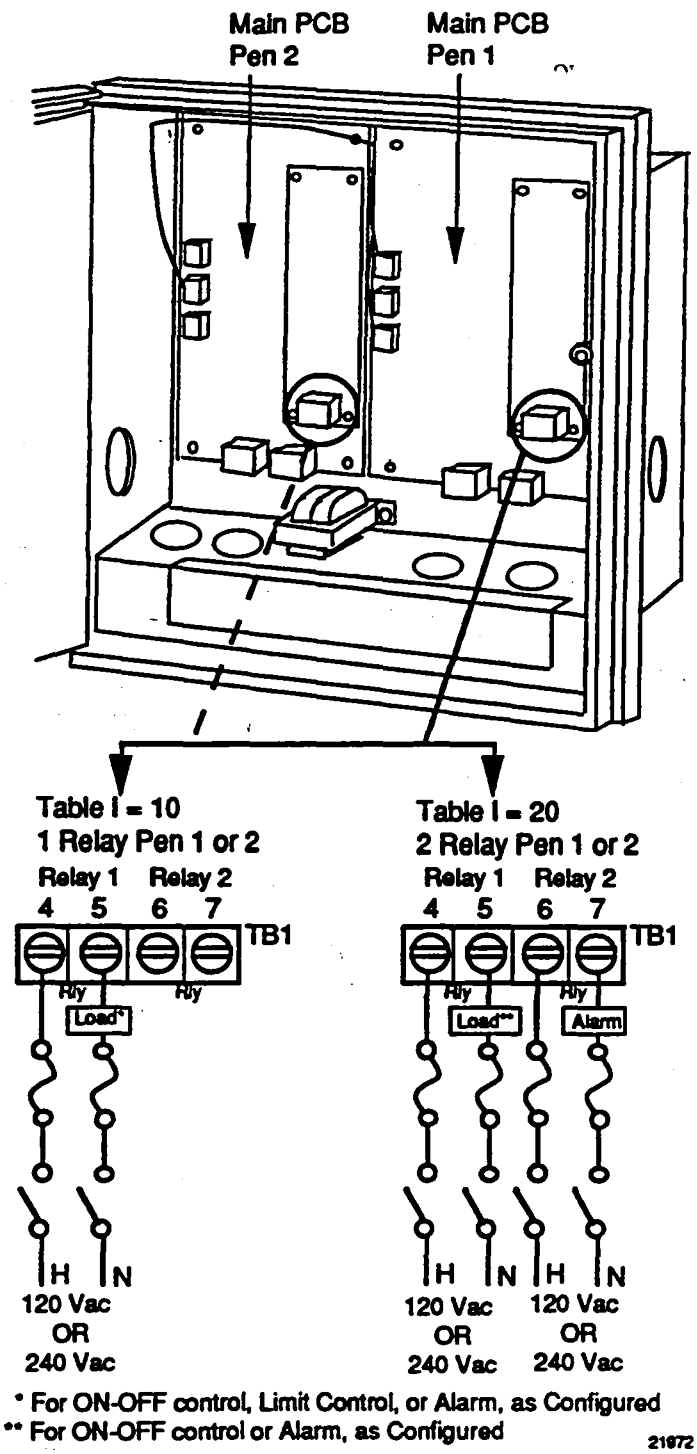
Table 4-8 Relay Output Wiring - 1 or 2 Pen Models

Step	Action
1	Open the recorder door. Loosen the captive screw in the chart plate and swing the plate out.
2	Locate terminal block TB1 on the bottom edge of the Output printed circuit board on the Main printed circuit board for pen 1 or pen 2 (refer to Figure 4-8 for location).
3	Run the output wires through the desired knockout. DO NOT bundle them with input wires.
4	Strip 3/4-inch maximum of insulation from the end of each wire and form end to fit under a screw connection.
5	Insert the wires under the appropriate screws for the applicable relay output as shown (refer to Figure 4-8). Tighten the screws to secure the wires.

Continued on next page

Relay output wiring (1 or 2 Pen Models), continued

Figure 4-8 Relay Output Wiring - 1 or 2 Pen Models



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Relay output wiring (2 Pen Models)

You can wire the Relay Output as follows:

For 1 Relay per pen - 2 pen models (Model Number Table 1 = 11), or

For 2 Relays per pen - 2 pen models (Model Number Table 1 = 22)

ATTENTION

Make sure you have configured the recorder to provide the desired control/alarm function and action, as applicable.
Refer to *Section 2 - Recording Set Up.*

Refer to Figure 4-9 and follow the procedure in Table 4-9 to wire the Relay Outputs.

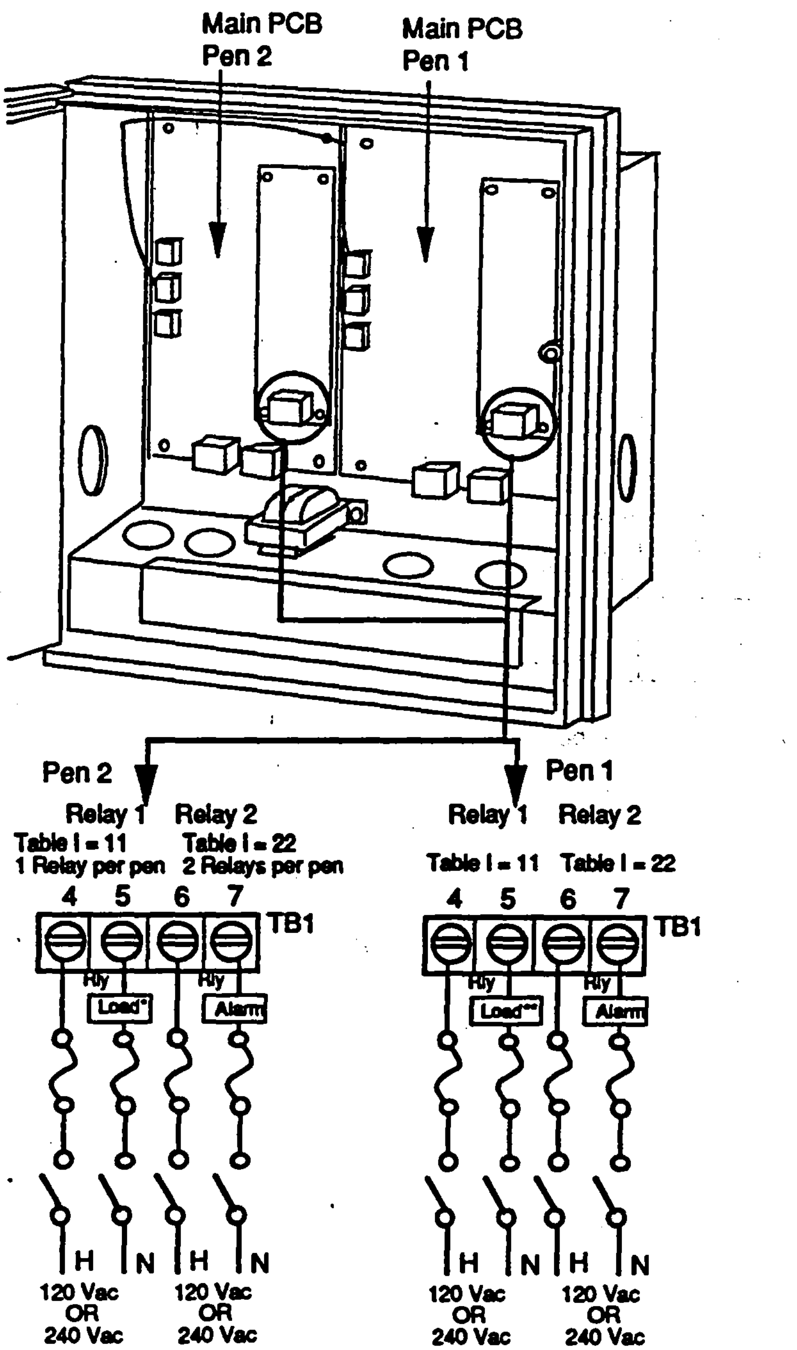
Table 4-9 Relay Output Wiring - 2 Pen Models

Step	Action
1	Open the recorder door. Loosen the captive screw in the chart plate and swing the plate out.
2	Locate terminal block TB1 on the bottom edge of the Output printed circuit board on the Main printed circuit board for pen 1 and the Output printed circuit board on the Main printed circuit board for pen 2 (refer to Figure 4-9 for location).
3	Run the output wires through the desired knockout. DO NOT bundle them with input wires.
4	Strip 3/4-inch maximum of insulation from the end of each wire and form end to fit under a screw connection.
5	Insert the wires under the appropriate screws for the applicable relay output as shown (refer to Figure 4-9). Tighten the screws to secure the wires.

Continued on next page

Relay output wiring (2 Pen Models), contnued

Figure 4-9 Relay Output Wiring - 2 Pen Models



* For Table 1 = 11, load is Alarm, ON-OFF control or Limit control for given pen, as configured

** For Table 1 = 22, load is ON-OFF control or Alarm control for given pen, as configured

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Section 5 – Operation and Maintenance

5.1 Overview

Introduction

This section provides procedures and reference data for operating the recorder and for doing routine maintenance tasks. It assumes that the recorder has been properly prepared, mounted, and wired in accordance with the instructions in Sections 2, 3, and 4.

Some of the procedures in this section are required only initially, and some are required randomly, as conditions dictate. Once the recorder is up and running, operator actions are required infrequently and are straightforward.

What's in this section?

This section contains the following information:

5.2 Preparing the Recorder for Operation

Introduction

Before applying power to the recorder, complete these preliminary preparation tasks to prepare your recorder for operation.

ATTENTION If you ran the Pre-Setup Operational Check (subsection 1.3), you can skip this procedure.

WARNING Never access components inside the case with power applied.

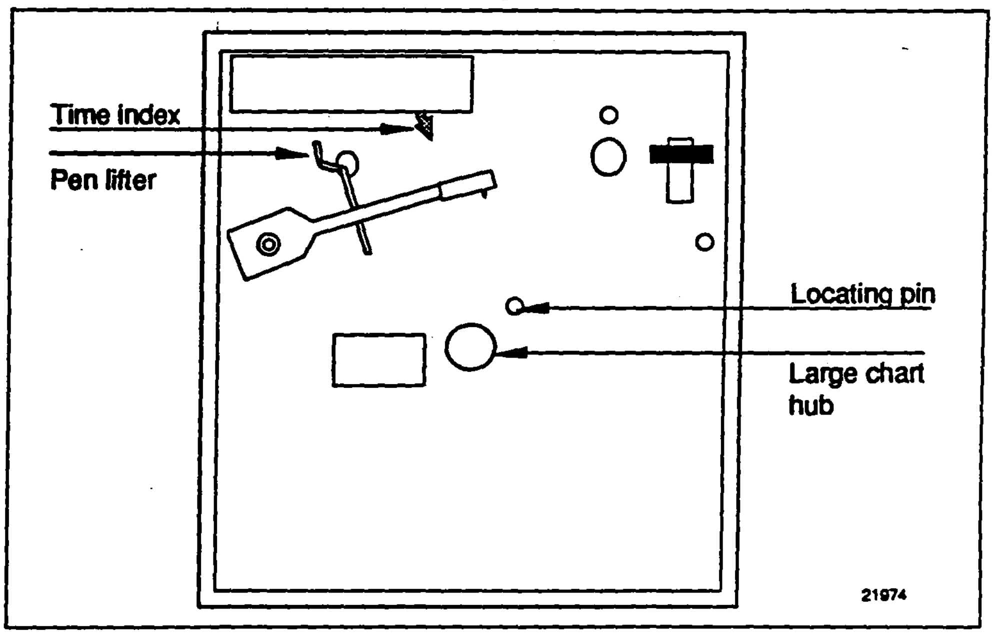
Procedure

Refer to Figure 5-1 to identify the basic chart plate components and follow the procedure in Table 5-1 to prepare the recorder for operation.

Table 5-1 Preparing the Recorder for Operation

Step	Action
1	Push in the button on the door and swing it open.
2	Pull up on the pen lifter to raise the pen(s) from the chart plate and remove the protective cap from the pen tip.
3	Slip the new chart under the pen lifter, pen and time index, and press it into place over the chart hub and locating pin.
4	Be sure that the chart zero, full scale settings, and alarm/control setpoints are correct (see Sections 2 and 3).

Figure 5-1 Basic Chart Plate Components



5.3 Running the Optional Self-Test

Introduction

You can have the recorder run its self-test when power is applied by setting a DIP switch and slide-switch on the Main printed circuit board.

- This test verifies that the electronic components and the pen and chart drive functions are operating properly by printing a step pattern, which is independent of any chart settings, with horizontal lines drawn at each 10% increment on the chart.
- The test will run for one complete revolution of the chart, so it will take a while to complete.
- You do not have to run the self-test before putting the recorder into operation, but doing so will verify the general operational status of the recorder.

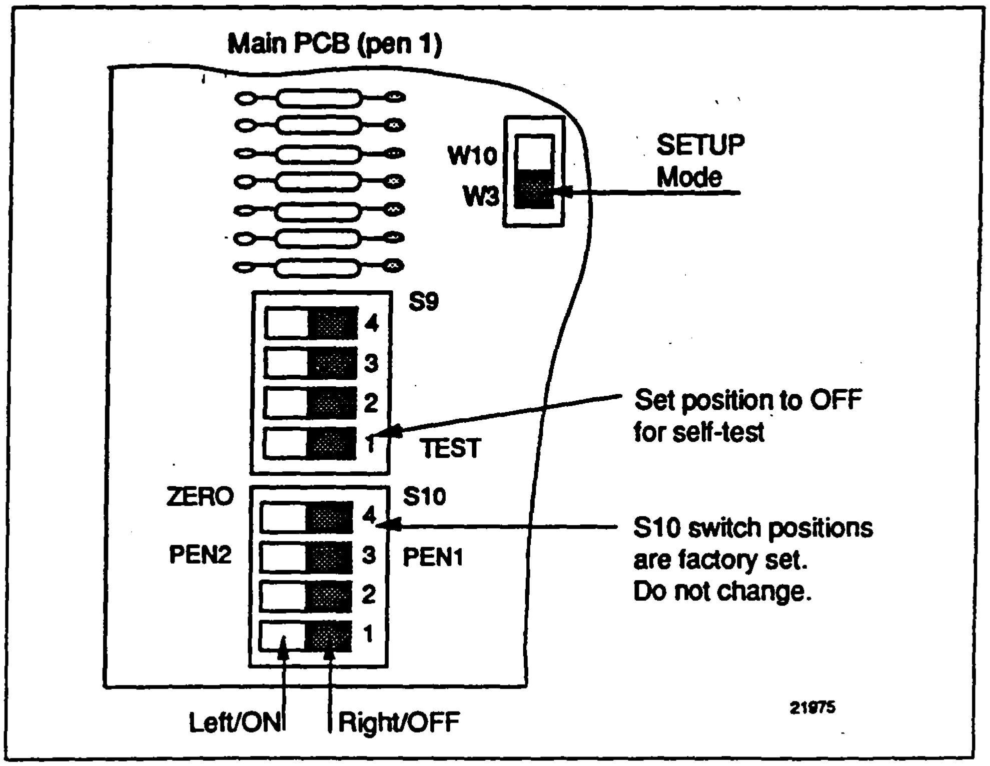
ATTENTION If the self-test does not run, recheck the DIP switch and jumper positions as well as power connections. Be sure that all the cable plugs are fully seated on the connectors on the Main printed circuit board.

WARNING Do not make DIP switch changes with power applied to the recorder since the chance for electrical shock exists.

Procedure

Refer to Figure 5-2 for DIP-switch and jumper locations and follow the procedure in Table 5-2 to run the self-test.

Figure 5-2 DIP Switch and Jumper Locations for Running the Self-Test



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Procedure, continued

Table 5-2 Running the Self-Test

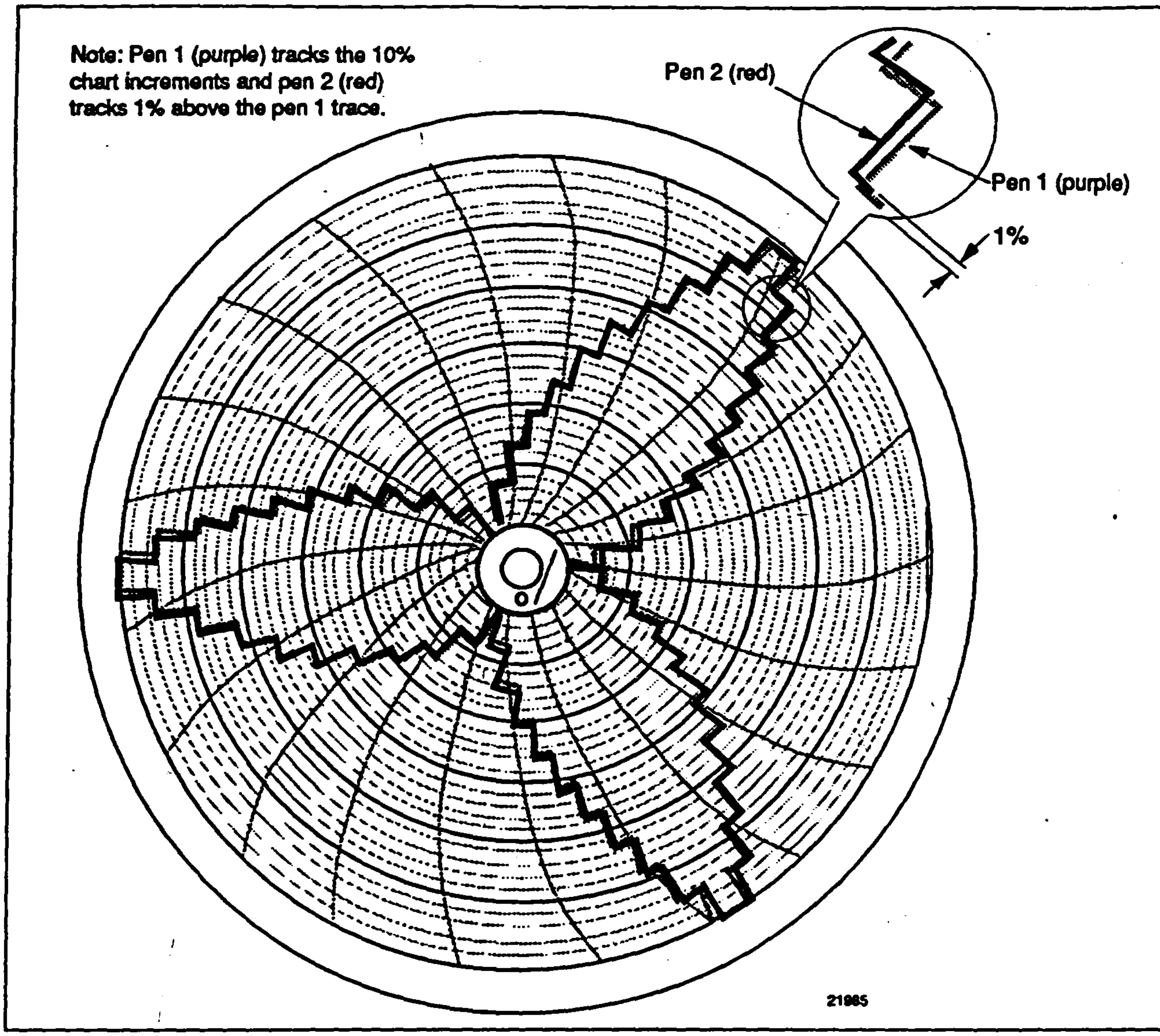
Step	Action
1	Loosen the captive screw in the chart plate and swing the chart plate out.
2	Locate DIP switch S9 on the lower left side of the Main printed circuit board for Pen #1 (see Figure 5-2 for location).
3	Set position 1 to the right/OFF.
4	Find W3/W10 slide-switch, which is located just to the right and above S9 DIP-switch on the Main printed circuit board for Pen #1, and put it in its W3 position for Set-Up mode.
5	Repeat steps 2 through 5 for Pen #2 Main printed circuit board.
CAUTION If your recorder has relay output, the relay(s) will be turned ON/OFF during the self-test. Be sure that your process can tolerate some upsets during the self-test cycle, or disconnect the output wiring.	
6	Be sure the cap is removed from the pen tip and the chart is installed (see subsection 5.4 - Start-up). Close the chart plate, apply power to the recorder, and check periodically to see that it is generating a step pattern on the chart as shown in Figure 5-3.
ATTENTION You can interrupt the self-test cycle by removing power and returning the slide-switch to its W10 position.	
7	At the completion of the self-test, the recorder automatically returns to the Run mode.
8	If you do not want the self-test to run every time power is cycled On/Off, return the slide-switch to the W10 position.

Continued on next page

Chart step pattern

Figure 5-3 is a typical chart step pattern generated by the recorder in the self-test.

Figure 5-3 Typical Chart Step Pattern



5.4 Start-up

Procedure

Once the recorder is Set up, mounted, wired, has had the chart installed and the operating parameters are set, you only have to:

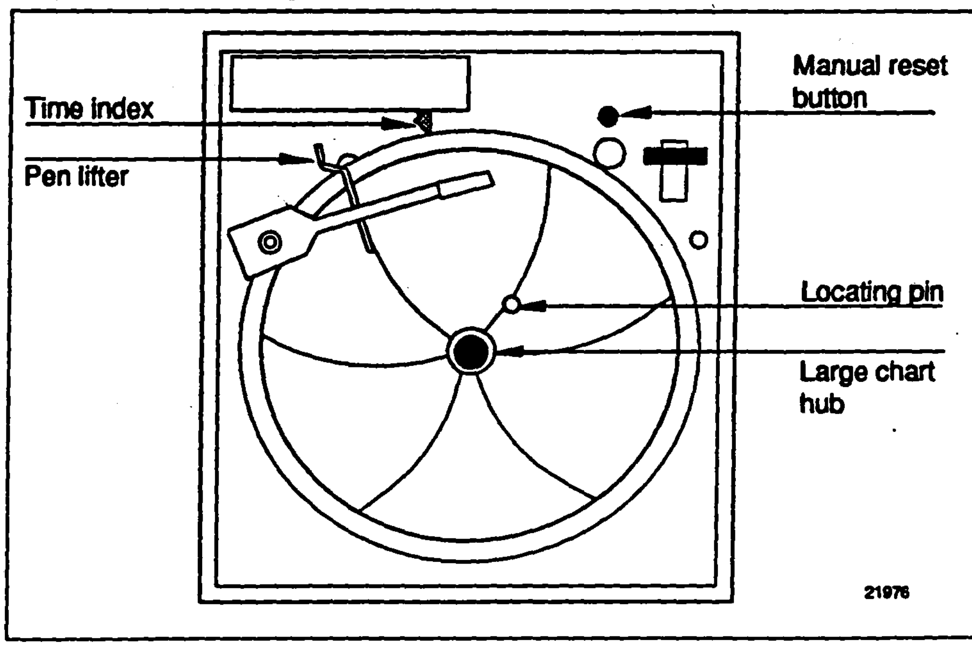
- set the chart time
- apply the power
- manually reset the limit relay, if the recorder is set-up for Limit control.

Refer to Figure 5-4 for the component locations and follow the procedure in Table 5-3 start-up the recorder.

Table 5-3 Start-Up Procedure

Step	Action
1	Push in the button on the door and swing it open.
2	Pull up the pen lifter to raise the pen(s) from the chart plate.
3	Grasp the chart hub and locating pin and turn the chart until the desired time line on the chart is aligned with the time index on the chart plate and Pen #1. Push down the pen lifter to return the pen(s) to the chart.
4	Close the door and apply power. The recorder pen will start to track the input value, after pen initialization.
5	If the Limit control output relay is latched at start-up, open the door and press the reset button on the chart plate to reset the relay.

Figure 5-4 Setting Chart Time to Time Index



5.5 Routine Maintenance

Introduction

The DR4200 recorder does not require any periodic maintenance as such. You will, however, have to replace the chart and ink cartridges as required.

Also, it does not require field calibration since its input range data including zero and full scale values are continually read and the input value is auto-calibrated.

However, humidity can affect the size of the chart such that the pen is offset from the proper chart increment. See subsection 6.5 - *"Checking Electrical Pen Alignment at Span and Zero"* to be sure that the pen and chart are aligned.

Replacing the ink cartridge

Refer to Figure 5-5 and follow the procedure in Table 5-4 to replace the ink cartridge.

Table 5-4 Replacing the Ink Cartridge

Step	Action
1	Remove the power from the recorder. Push in the button on the door and swing the door open.
2	Pull up on the pen lifter to raise the pen(s) from the chart plate.
CAUTION Be careful not to move the pen arm while removing and installing the ink cartridge.	
3	Unclip and remove the purple (Pen #1) or red (Pen #2) ink cartridge from the pen arm.
4	Remove the protective cap from the pen tip on the new cartridge and open its clip.
5	Slide the new cartridge onto the pen arm so that its tip fits into the notch at the end of the pen arm and close the clip to secure the cartridge to the pen arm.
6	Push down the pen lifter to return the pen tip to the chart.
7	Close the door and apply power.

Continued on next page

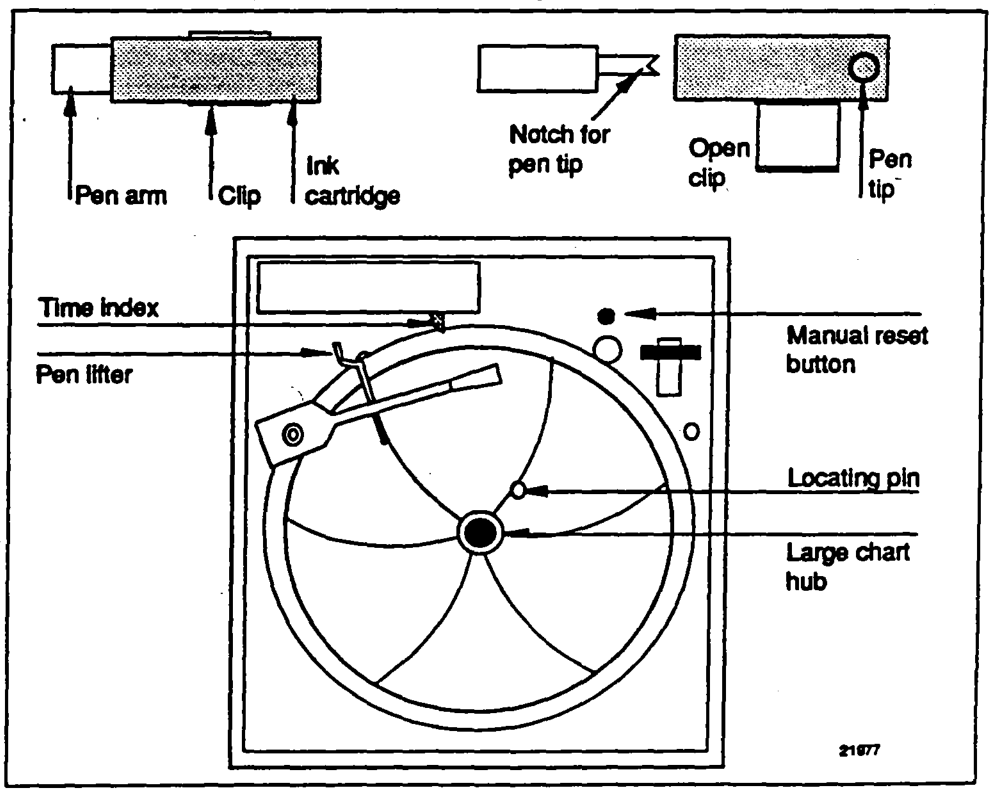
Replacing the chart

Refer to Figure 5-5 and follow the procedure in Table 5-5 to replace the chart.

Table 5-5 Replacing the Chart

Step	Action
1	Push in the button on the door and swing the door open.
2	Pull up on the pen lifter to raise the pen(s) from the chart plate.
3	Lift the chart from the hub and locating pin and slide it from under the pen(s) to remove it from the chart plate.
4	Slip the new chart under the pen lifter, pens and time index; and press the chart into place over the chart hub and locating pin.
5	Grasp the chart hub and locating pin and turn the chart until the desired time line on the chart is aligned with the time index on the chart plate and Pen #1. Push down the lifter to return the pen(s) to the chart.
6	Close the door.

Figure 5-5 Replacing the Ink Cartridge and Chart.



Section 6 – Service/Troubleshooting

6.1 Overview

Introduction

This section provides general troubleshooting procedures based on some visual failure symptoms. It also contains a procedure for aligning the pen arm with the chart.

- Using an optimum replacement unit repair philosophy, trouble is traced to a printed circuit board (PCB) hardware level rather than to an individual PCB/hardware assembly component level.
- While troubleshooting the DR4200 is straightforward, we recommend that only trained service technicians repair the recorder.

What's in this section

This section contains the following topics:

6.2 Troubleshooting

Introduction

Before troubleshooting hardware and software related problems, we recommend that you check for Installation and Setup related problems.

- Check *Section 2 - Recording Set-up and Section 4 - Installation"* of this manual to be sure that the recorder is set-up and wired correctly.
- Run the Self-Test that is outlined in the *Section 5 - Operation/Maintenance* to confirm the existing symptom.

Symptoms

The following visual failure symptoms identify some problems that you may observe during operation. There are progressive corrective steps given to aid in finding and fixing the problem.

A list of symptoms is given in Table 6-1 and a procedure reference that will help you troubleshoot the symptom.

Table 6-1 Failure Symptoms and Procedure Reference

Symptom	Troubleshooting Procedure
Recorder will not operate	1
Recorder operation normal but pen trace incorrect	2
Chart rotates at the wrong speed or not rotating	3
Pen remains at the high or low end of the range	4

Continued on next page

Procedure #1

Symptom: Recorder will not operate.

Follow the procedure in Table 6-2 to troubleshoot the above mentioned symptom.

Table 6-2 Recorder Will Not Operate

What to do	How to Do It or Where to Find the Data
1. Check the supply voltage.	1. Measure the line voltage across the connections to TB1 on the Main printed circuit board for Pen #1.
2. Check the connections to TB1 on the Main printed circuit board for Pen #1	2. Refer to the wiring portion of *Section 4 - Installation*.
3. Check Fuse F1.	3. Measure the continuity across the fuse.
4. Check the Power Requirement Setup.	4. Refer to *Section 2 - Recording Set Up.*
5. Check the Pen Setup	5. Refer to *Section 2 - Recording Set Up*
6. Replace the Main printed circuit board.	6. Refer to subsection 6.3 - *"Replacement Procedures"*

Procedure #2

Symptom: Recorder operation normal but pen trace incorrect.

Follow the procedure in Table 6-3 to troubleshoot the above mentioned symptom.

Table 6-3 Pen Trace Incorrect

What to do	How to Do It or Where to Find the Data
1. Check the ink cartridge for proper installation.	1. Reposition or replace the pen cartridge. If the pen arm is severely warped and prevents proper installation, replace the pen arm.
2. Check that the chart agrees with actuation type and chart setup.	2. Replace the wrong chart with the correct chart. Refer to *Section 2 - Recording Set Up*.
3. Check the sensor for proper type and ability to function.	3. Verify actuation Set Up data and operation of the sensor.
4. Replace the Servo Plate assembly.	4. Refer to Subsection 6.3*"Replacement Procedures"*.
5. Replace the Main printed circuit board.	5. Refer to subsection 6.3 *"Replacement Procedures"*.

Continued on next page

Procedure #3

Symptom: Chart rotates at wrong speed or not at all.

Follow the procedure in Table 6-4 to troubleshoot the above mentioned symptom.

Table 6-4 Chart Rotates at Wrong Speed or Not At All.

What to do	How to Do It or Where to Find the Data
1. Check the chart installation.	1. Be sure the locating pin is in the drive hole on the chart.
2. Check the Set Up chart speed value and change, if required.	2. Refer to *Section 2 - Recording Set Up*
3. Check the motor cable plug connection at J3 connector on the Main printed circuit board for Pen #1.	3. Visually examine the plug and reseat it.
4. Replace the Chart Motor.	4. Refer to subsection 6.3 *"Replacement Procedures"*.
5. Replace the Main printed circuit board.	5. Refer to Subsection 6.3 *"Replacement Procedures"*.

Procedure #4

Symptom: Pen Remains at High or Low End of Range.

Follow the procedure in Table 6-5 to troubleshoot the above mentioned symptom.

Table 6-5 Pen Remains at High or Low End of Range

What to do	How to Do It or Where to Find the Data
1. Check the sensor and leadwires for continuity. Check the input connections to TB2 on the Main printed circuit board.	1. Replace the sensor or leadwires as needed. Refer to the wiring portion of *Section 4 - Installation.*
2. Check the pen and actuation type Set Up data.	2. Refer to *Section 2 - Recording Setup.*
3. Run the self-test.	3. Refer to *Section 5- Operation and Maintenance*
4. Replace the Servo Plate assembly.	4. Refer to subsection 6.3 *"Replacement Procedures"*.
5. Replace the Main printed circuit board.	5. Refer to subsection 6.3 *"Replacement Procedures"*.

6.3 Replacement Procedures

Introduction

The procedures listed here assume that the chart door is opened, the chart plate is swung out, and power is removed. Refer to *Section 7 - Parts List* for a general orientation of the components.

WARNING To avoid personal injury, never access the components inside the case with power applied.

Replacing the No. 1 pen arm

Follow the procedure in Table 6-6 to replace the No.1 pen arm.

Table 6-6 Replacing the No.1 Pen Arm

Step	Action
1	Note the location of the pen (purple) on the chart. Pull the lifter up to raise the pen from the chart.
2	Remove the ink cartridge.
3	Remove the screw, lockwasher, and flat washer that hold the pen arm to the servo shaft. Remove the pen arm.
4	Replace the pen arm, flat washer, lockwasher, and screw, but leave the screw slightly loose. Replace the ink cartridge.
5	Push down the pen lifter and carefully position the pen to the location noted in step 1. Tighten the pen arm screw.
6	Refer to subsection 6.4 and 6.5 in this section.

Continued on next page

Replacing the No.2 pen arm

Follow the procedure in Table 6-7 to replace the No.2 pen arm.

Table 6-7 Replacing the No.2 Pen Arm

Step	Action
1	Note the location of pens on the chart. Pull the lifter up to raise the pens from the chart.
2	Remove the ink cartridges.
3	Remove the screw, lockwasher, and flat washer that hold the #1 pen arm to the servo shaft. Remove the pen arm.
4	Remove the screw, lockwasher, and flat washer that hold the #2 pen arm to the servo shaft. Remove the pen arm.
5	Replace the #2 pen arm, flat washer, lockwasher, and screw, but leave the screw slightly loose.
6	Replace the red ink cartridge on the No.2 pen arm..
7	Push down the pen lifter and carefully position the #2 pen to the location noted in step 1. Tighten the No.2 pen arm screw.
8	Replace the No.1 pen arm, flat washer, lockwasher, and screw, but leave the screw slightly loose.
9	Raise the pen lifter and replace the purple ink cartridge on the No.1 pen arm.
10	Push down the pen lifter and carefully position the #1 pen to the location noted in step 1. Tighten the No.1 pen arm screw.
11	Refer to subsection 6.4 and 6.5 in this section.

Continued on next page

Replacing the servo plate

ATTENTION Complement this procedure with the appropriate pen arm replacement procedure - No.1 pen arm for 1-pen model or No.2 pen arm for 2-pen model.

Follow the procedure in Table 6-8 to replace the Servo Plate.

Table 6-8 Replacing the Servo Plate

Step	Action
1	Remove the pen arm(s).
2	Note how the spring(s) is (are) attached to the servo plate. Disconnect the spring(s) from the servo plate.
3	Disconnect the No.1 pen motor cable plug from J1 connector on the Main printed circuit board for pen #1 and the No.2 pen motor cable from J2 connector on the Main printed circuit board for pen #2. Remove the cable(s) from the clamps in the rear of the case.
4	Remove the screws that hold the servo plate to the chart plate. Remove the servo plate.
5	Replace the servo plate and secure with the screws. Dress the cable(s) in the clamps and connect the cable plugs to the appropriate connector on the given Main printed circuit board. Connect the spring(s) to the servo assembly as noted in step 2.
6	Replace the pen arm(s).
7	Refer to subsection 6.4 and 6.5 n this section.

Replacing the chart motor

Follow the procedure in Table 6-9 to replace the Chart Motor.

Table 6-9 Replacing the Chart Motor

Step	Action
1	Pull up the pen lifter to raise the pen(s) from the chart.
2	Remove the chart. Pull the chart hub assembly from the motor shaft.
3	Disconnect the motor cable plug from J3 connector on the Main printed circuit board for Pen #1 and remove the cable from the clamps in the rear of the case.
4	Remove the screws holding the motor to the chart plate and remove the chart motor.
5	Replace the motor and secure it with screws. Dress the cable in the clamps and connect plug to J3 on the Main PC board for Pen #1.
6	Push the chart hub assembly that was removed in step 2 onto the motor shaft.
7	Close the chart plate and replace the chart. Set the chart time to the time index on the chart plate and push down the pen lifter.

Continued on next page

Replacing the main printed circuit board

Follow the procedure in Table 6-10 to replace the Main printed circuit board.

Table 6-10 Replacing the Main Printed Circuit Board

Step	Action
1	Tag and disconnect all the cable plugs from the connectors and the wiring from the terminal blocks on the Main printed circuit board.
2	Remove the screws from the corners of the Main printed circuit board and lift the board from the case.
ATTENTION If there is an Output printed circuit board mounted on the Main printed circuit board go to step 3, if not go to step 9.	
3	Remove the 4-pin connector from J3 on the Main printed circuit board.
4	Remove the Output printed circuit board from the four spacers holding it to the Main PCB. Remove the four spacers from the Main printed circuit board.
5	Push the four plastic spacers into the holes on the right side of the new Main printed circuit board.
6	Hold the Output printed circuit board so that its mounting holes align with the spacers and plug the multi-pin connector from the Output printed circuit board into J4 connector on the Main printed circuit board. Be sure that the plug positions are aligned and matched with the pins on J4.
7	Push down on each corner of the Output printed circuit board in turn to seat the board on the spacers.
8	Plug the 4-pin connector from the transformer on the Output printed circuit board into the J3 connector on the Main printed circuit board.
9	Position the new Main printed circuit board in the case and secure with the screws.
10	Replace the cable plugs and wiring to the connectors and terminal block as noted in step 1.
11	Refer to *Section 3 - Optional Relay Output Set Up*and *Section 5 - Operation and Maintenance* to check the Main printed circuit board setup and operating parameter values.

6.4 Checking Mechanical Pen Alignment at Zero

Introduction

You can have the recorder drive the pen to the zero position on the chart by setting a DIP switch and slide-switch on the Main printed circuit board. This will let you mechanically adjust the pen tip to the zero line on the chart.

Procedure

Refer to Figure 6-1 and follow the procedure in Table 6-11 to check the mechanical pen alignment at zero.

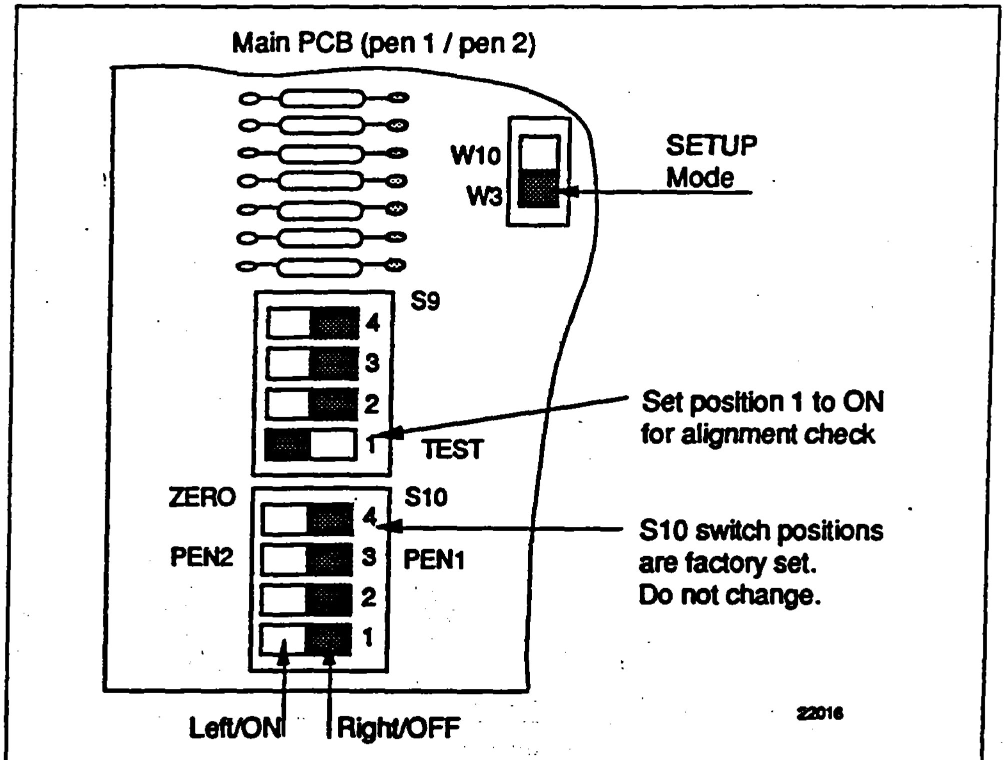
Table 6-11 Check the Mechanical Pen Alignment

Step	Action
1	Loosen the captive screw in the chart plate and swing the chart plate out.
WARNING Do not make DIP switch changes with power applied to the recorder, since the chance for electrical shock does exist.	
2	Locate DIP Switch S9 on the lower left side of the Main printed circuit board (see Figure 6-1).
3	Set position 1 on the S9 switch to left/ON.
4	Locate the W3/W10 slide-switch which is just to the right and above S9 DIP-switch on the Main printed circuit board (see Figure 6-1).
5	Put the slide-switch in its W3 position for SETUP mode, and close the chart plate.
6	Apply power to the recorder.
ATTENTION If the recorder is a 2-pen model, repeat steps 2 through 6 on the Main printed circuit board for Pen #2 to adjust the Pen #2 position first.	
7	Loosen the screw holding the No.1 pen arm to the servo shaft and move the pen arm to access the locking screw in the No.2 pen arm, if applicable.
8	Align the pen tip for the No. 2 pen with the zero line on the chart and tighten the locking screw, if applicable.
9	Align the pen tip for the No. 1 pen with the zero line on the chart and tighten the screw.
10	Remove the power, open the door, and swing the chart plate out. Return the slide-switch to the W10 position.
11	Close the chart plate and door and apply power.

Continued on next page

Procedure, continued

Figure 6-1 DIP Switch and Jumper Locations for Pen Alignment Check



6.5 Checking the Electrical Pen Alignment at Span and Zero

Introduction

If the pen trace does not track at the correct chart increment with a known input value, you can use the following procedures to adjust the pen travel at zero and span (full scale) to compensate for the effects of humidity on the chart size.

Equipment needed

The following items will be needed to help you accomplish the pen alignment:

- The correct chart for your application
- Voltage and resistance equivalents for the range values of your input type - See Table 6-12
- Voltage/current calibration source for thermocouple and linear actuations
- Decade box as a calibration source for RTD actuation
- Copper leads
- Thermocouple extension wire for thermocouple actuation.

Voltage/ resistance equivalents

Use the Voltage and Resistance equivalents listed in Table 6-12 when making your alignment check.

Table 6-12 Voltage and Resistance Equivalents for 0% and 100% Range Values

Sensor Type	PV Input Range		Range Values	
Thermocouples	°F	°C	0%	100%
J	0 to 1600	−18 to 871	−0.885 mV	50.059 mV
K	-320 to 2500	−196 to 1371	−5.822 mV	54.845 mV
T	-300 to 700	−184 to 371	−5.341 mV	19.095 mV
RTD (IEC=0.00385) 100 Ω	-300 to 900	−184 to 484	25.18 Ω	274.96 Ω
Milliamps	0 to 20 mA 4 to 20 mA		0 mA 4 mA	20 mA 20 mA
Millivolts	0 to 20 mV		0 mV	20 mV
	0 to 50 mV		0 mV	50 mV
Volts	0 to 5 Volts		0 Volt	5 Volts
	1 to 5 Volts		1 Volt	5 Volts

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6.5 Checking the Electrical Pen Alignment at Span and Zero, Continued

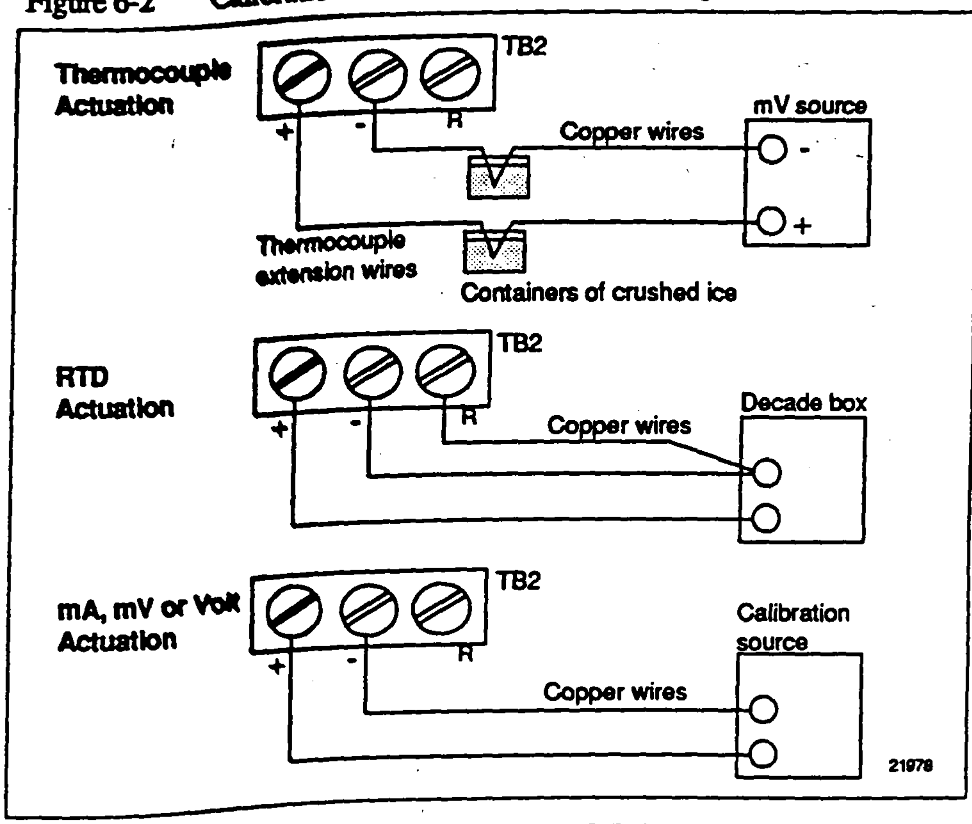
Preparing for alignment check

Refer to Figure 6-2 and follow the procedure in Table 6-13 to prepare the recorder for an alignment check.

Table 6-13 Preparing for Alignment Check

Step	Action
1	Remove the power from the recorder, open the door, and swing the chart plate out.
2	Disconnect the input connections from the terminal block TB2 on the bottom edge of the Main printed circuit board for Pen #1.
3	Connect the calibration source as appropriate for the given actuation (see Figure 6-2 for connections).
4	If required, use Table 6-12 to convert zero and full scale actuation value to the equivalent mV or resistance values.
5	Set the calibration source to the equivalent zero value.
6	Apply power and let the recorder warm-up for thirty minutes.

Figure 6-2 Calibration Source Connections for Alignment



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Making the alignment check

Refer to Figure 6-3 and follow the procedure in Table 6-14 to make the alignment check.

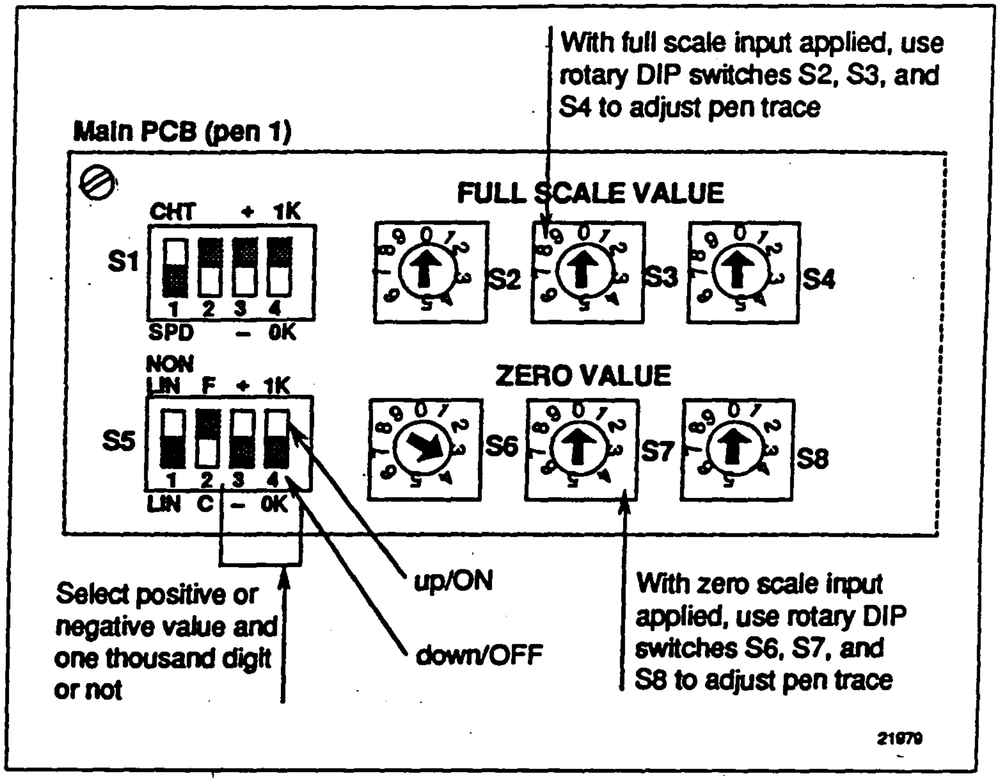
Table 6-14 Making the Alignment Check

Step	Action
1	Set the calibration source to the equivalent full scale value.
2	Check that the pen trace tracks at the full-scale chart increment.
3	Use rotary DIP switches S2, S3, and S4 to raise or lower the full scale value to move the pen up or down as required so that it tracks at full scale chart increment. See Figure 6-3.
ATTENTION You may have to change the DIP switch S1 position 3 or 4 to get negative values or values above or below 1000.	
4	Set the calibration source to the equivalent zero scale value.
5	Check that the pen trace tracks at the zero chart increment.
6	Use the rotary DIP switches S6, S7, and S8 to raise or lower the zero scale value to move the pen up or down as required so it tracks at zero scale chart increments. See Figure 6-3.
ATTENTION You may have to change DIP switch S5 position 3 or 4 to get negative values or values above or below 1000.	
7	Remove the power, calibration source and connections, and connect the input actuation to TB2.
8	Repeat the procedure for Pen #2, if applicable.
9	Close the chart plate, door, and return the recorder to operation.

Continued on next page

Making the alignment check, continued

Figure 6-3 Adjustment for Span (full scale) and Zero



Section 7 – Parts List

7.1 Overview

Introduction

This section provides the replacement parts lists for the DR4200 Model GP Circular Chart Recorder. Most parts are supplied on an optimum replacement unit basis; that is, part numbers are given for complete printed circuit boards rather than for individual PCB components.

- The figures that follow are exploded views of the DR4200 Model GP recorder. Each part is labeled with a key number and the key numbers are listed in tables with associated part numbers.
- When ordering parts, be sure to specify your recorder's serial and model numbers (on chartplate) as well as the part identification.

What's in this section?

This section contains the following topics:

7.2 Exploded Views

Door assembly

Figure 7-1 is an exploded view of the Door Assembly.

• Table 7-1 is a list of the associated part numbers.

Figure 7-1 Door Assembly

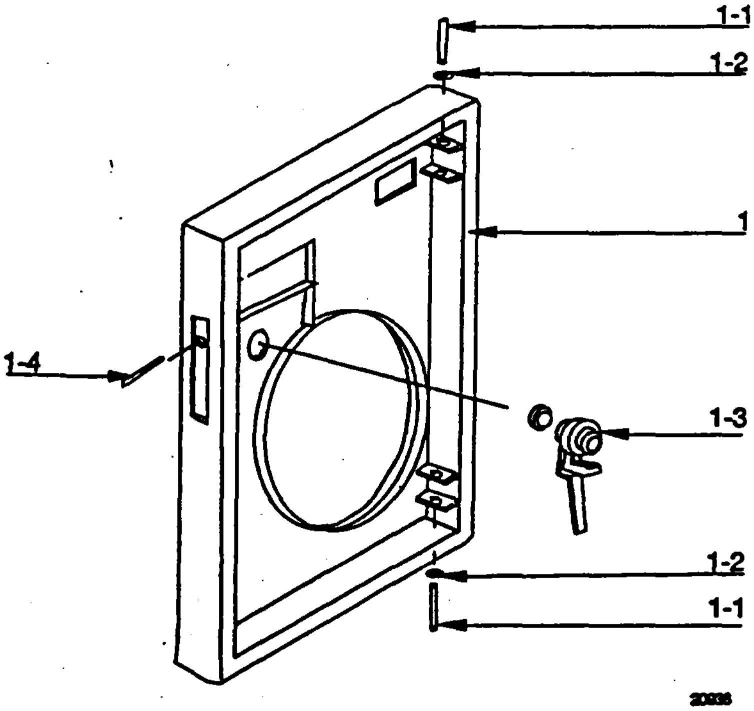


Table 7-1 Door Assembly Parts

Key	Part Number	Description	Recommended Spare Parts Per 10	Recommended Spare Parts Per 100	Quantity per Unit
1		Door Assembly			1
	30755825-501	Blue Door - Glass Window and Latch			
	30755825-502	Blue Door - Acrylic Window and Lock			
	30755825-503	Blue Door - Glass Window and Lock			
	30755825-504	Blue Door - Acrylic Window and Latch			
	30755825-505	Black Door - Glass Window and Latch			
	30755825-506	Black Door - Acrylic Window and Lock			
	30755825-507	Black Door - Glass Window and Lock			
	30755825-508	Black Door - Acrylic Window and Latch			
	30755825-509	Beige Door - Glass Window and Latch			
	30755825-510	Beige Door - Acrylic Window and Lock			
	30755825-511	Beige Door - Glass Window and Lock			
	30755825-512	Beige Door - Acrylic Window and Latch			
	30755825-513	Gray Door - Glass Window and Latch			
	30755825-514	Gray Door - Acrylic Window and Lock			
	30755825-515	Gray Door - Glass Window and Lock			
	30755825-516	Gray Door - Acrylic Window and Latch			
	30755825-517	Blue Door - Glass Window and Heavy Duty Latch			
	30755825-518	Blue Door - Acrylic Window and Heavy Duty Latch			
	30755825-519	Black Door - Glass Window and Heavy Duty Latch			
	30755825-520	Black Door - Acrylic Window and Heavy Duty Latch			
	30755825-521	Beige Door - Glass Window and Heavy Duty Latch			

Table 7-1 is continued on next page

Door assembly

Table 7-1 Door Assembly Parts, continued

Key	Part Number	Description	Recommended Spare Parts Per 10	Recommended Spare Parts Per 100	Quantity per Unit
1		Door Assembly, continued			1
	30755825-522	Beige Door - Acrylic Window and Heavy Duty Latch			
	30755825-523	Gray Door - Glass Window and Heavy Duty Latch			
	30755825-524	Gray Door - Acrylic Window and Heavy Duty Latch			
	30756045-501	Heavy Duty Gray Door - Acrylic Window and Lock			
	30756045-502	Heavy Duty Blue Door - Acrylic Window and Lock			
	30756045-503	Heavy Duty Gray Door - Glass Window and Lock			
	30756045-504	Heavy Duty Blue Door - Glass Window and Lock			
	30756045-505	Heavy Duty Beige Door - Plastic Window and Lock			
	30756045-506	Heavy Duty Black Door - Plastic Window and Lock			
	30756045-507	Heavy Duty Beige Door - Glass Window and Lock			
	30756045-508	Heavy Duty Black Door - Glass Window and Lock			
	30756045-509	Heavy Duty Gray Door - Acrylic Window and Heavy Duty Latch			
	30756045-510	Heavy Duty Blue Door - Acrylic Window and Heavy Duty Latch			
	30756045-511	Heavy Duty Gray Door - Glass Window and Heavy Duty Latch			
	30756045-512	Heavy Duty Blue Door - Glass Window and Heavy Duty Latch			
	30756045-513	Heavy Duty Beige Door - Acrylic Window and Heavy Duty Latch			
	30756045-514	Heavy Duty Black Door - Acrylic Window and Heavy Duty Latch			
	30756045-515	Heavy Duty Beige Door - Glass Window and Heavy Duty Latch			
	30756045-516	Heavy Duty Black Door - Glass Window and Heavy Duty Latch			
1-1	(K)30756409-001	Hinge Pin*			2
1-2	(K)30756409-001	Retaining Ring*			2
1-3	(K)30756409-001	Latch without lock and with gasket	1	3	1
	30756584-001	Latch Assembly for Heavy Duty Door			
	30756584-002	Lock Assembly Kit			
1-4	(K)30756409-001	Latch Pin*			1
	30755822-001	Graphic Overlay for Door - not shown*			1

*Parts included with applicable door assembly.
(K) denotes that the part number is for the parts kit in which the described part is included. The described part cannot be ordered separately.

Chart plate

Figure 7-2 is an exploded view of the Chart Plate Assembly.
- Table 7-2 is a list of the associated part numbers.

Figure 7-2 Chart Plate Assembly

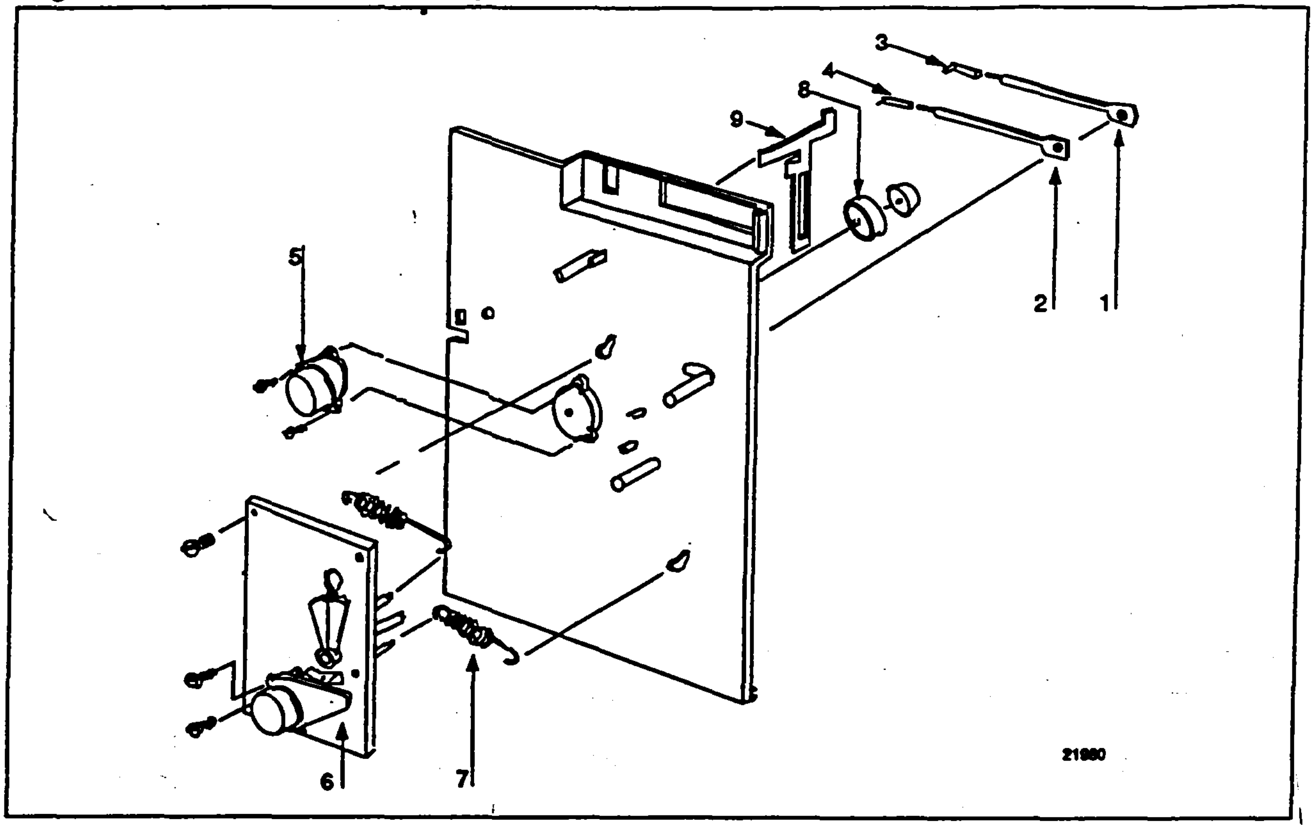


Table 7-2 Chart Plate Assembly Parts

Key	Part Number	Description	Recommended Spare Parts Per		Quantity per Unit
			10	100	
1	(K)30756409-002	No. 1 Pen Arm	1	5	1
2	(K)30756409-002	No. 2 Pen Arm (2-pen model only)	1	5	1
3	30735489-007	No. 1 Purple Pen Cartridge (Six Pack)	1	3	1
4	30735489-002	No. 2 Red Pen Cartridge (Six Pack)	1	3	1
5	30756113-501	Chart Motor	1	3	1
6	30755833-501 30755833-501	Servo Motor Assembly 1-pen model 2-pen model			1
7	(K)30756409-002	Spring, Tension			1/2
8	(K)30756150-001	Chart Hub Kit (includes 5 hubs and 5 adapters)			1
9	(K)30756409-002	Pen Lifter Retainer			1

(K) denotes that the part number is for the parts kit in which the described part is included. The described part cannot be ordered separately.

Continued on next page

Basic recorder components without options

Figure 7-3 is an exploded view of the Basic Recorder components without options.

• Table 7-3 is a list of the associated part numbers.

Figure 7-3 Basic Recorder Components without Options

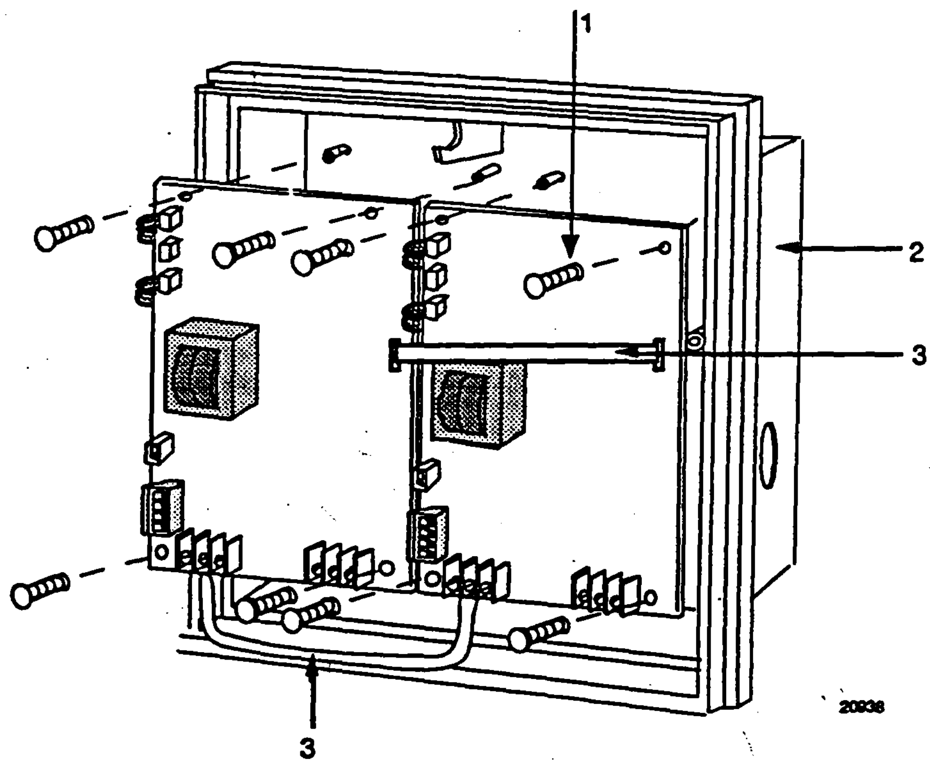


Table 7-3 Basic Recorder Parts Without Options

Key	Part Number	Description	Recommended Spare Parts Per		Quantity per Unit
			10	100	
1	30755804-501	Main Printed Circuit Board	1	3	1/2
2	30755800-501	Case	1	3	1
3	30757235-001	Cable Replacement kit	1	3	1

Continued on next page

Additional recorder components associated with options

Figure 7-4 is an exploded view of the Recorder components associated with options.

- Table 7-4 is a list of the associated part numbers.

Figure 7-4 Recorder Components Associated With Options

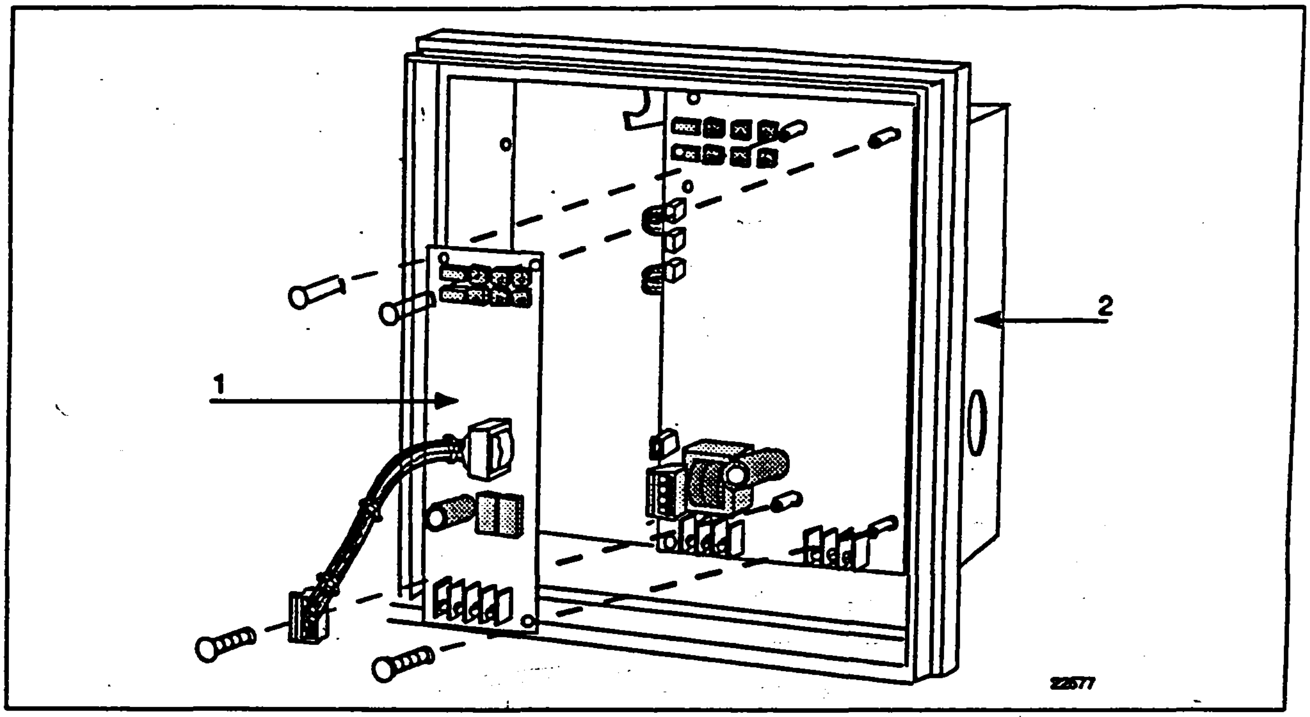


Table 7-4 Recorder Parts Associated With Options

Key	Part Number	Description	Recommended Spare Parts Per 10	Recommended Spare Parts Per 100	Quantity per Unit
1	30755808-501 30755808-502 30755808-504	Output Printed Circuit Board (includes manual reset switch assembly and four standoffs) – One relay – Two relays – FM approved Limit Control Relay	1	5	1/2 1
	(K) 30755980-003	Four-position connector			1

(K) denotes that the part number is for the parts kit in which the described part is included. The described part cannot be ordered separately.

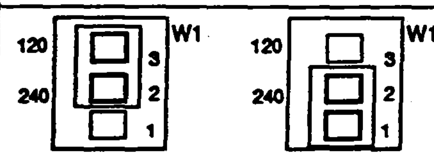
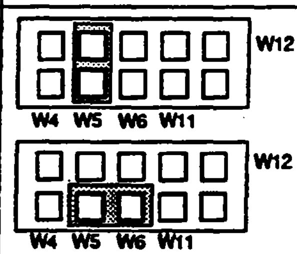
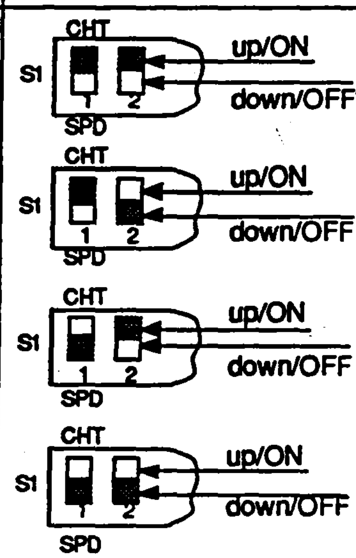
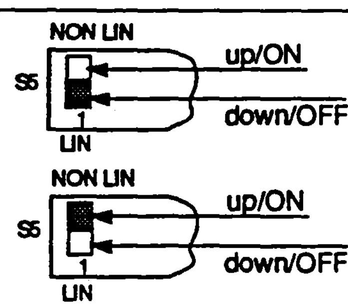
Appendix A

A.1 Summary of DIP Switch and Jumper Selections on Main Printed Circuit Board

Introduction

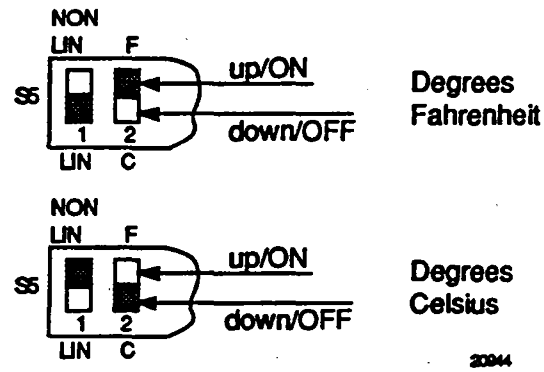
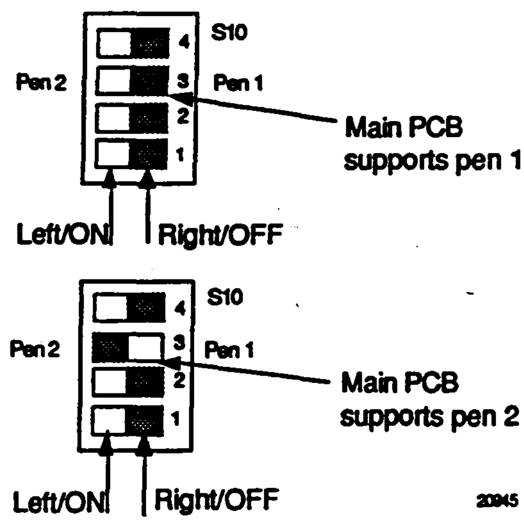
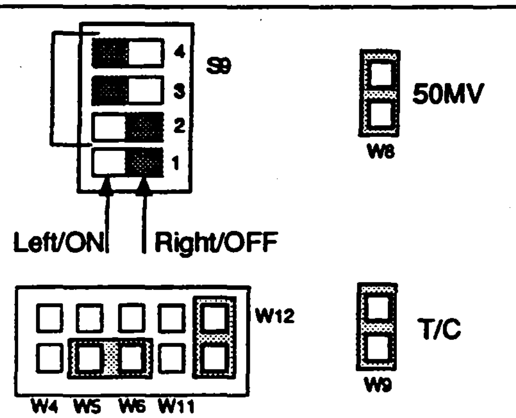
Table A-1 is a summary of all the DIP switch and jumper selections on the Main printed circuit board. The table lists the jumper or DIP switch number, its function, and a graphic view of the switches and jumpers selections.

Table A-1 Summary of DIP Switches and Jumpers

Jumper or DIP-Switch Number	Function	Selections
W1	Select power requirement.	 120 Vac 240 Vac 20940
W5/W6	Select upscale or downscale burnout.	 Downscale Burnout Upscale Burnout 20941
S1	Select chart speed with positions 1 and 2 on switch.	 8 hours TEST (For factory use only) 24 hours 7 days 20942
S5	Select chart type with position 1 on switch.	 Linear type Non-Linear type 20943

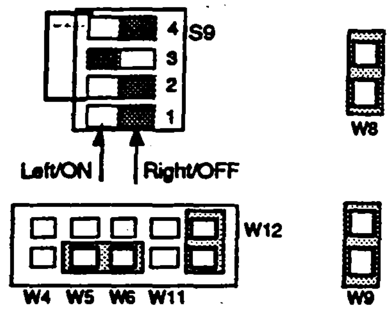
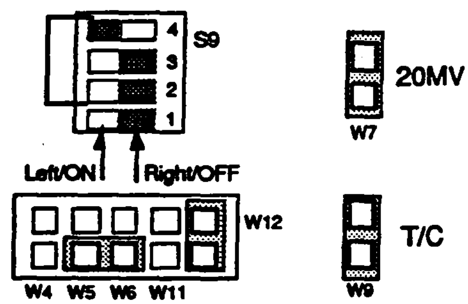
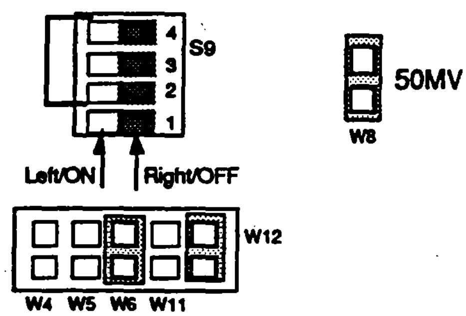
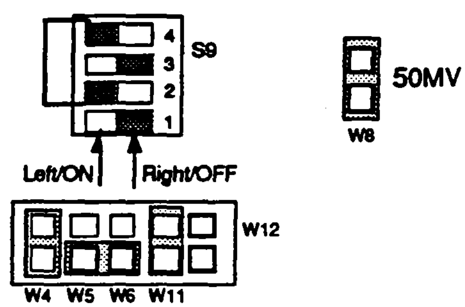
Continued on next page

Table A-1 Summary of DIP Switches and Jumpers, continued

Jumper or DIP-Switch Number	Function	Selections
S5	Select the temperature unit with position 2 on switch.	
S10	Verify the pen position for the Main printed circuit board with position 3 of the switch. CAUTION S10 switch positions are factory set - do not change without first contacting our technical assistance center.	
S9, W4, W6, W7, W8, W9, W11, W12	Select input actuation type/range with positions 2, 3, and 4; and jumpers.	 Type J thermocouple with upscale burnout 20946

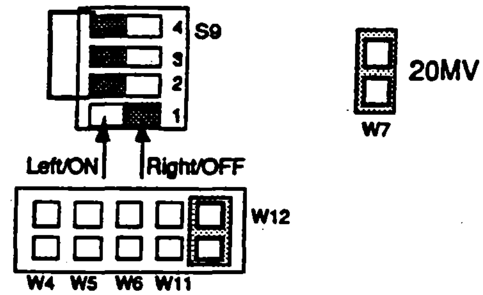
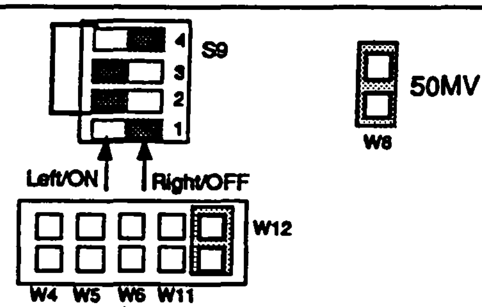
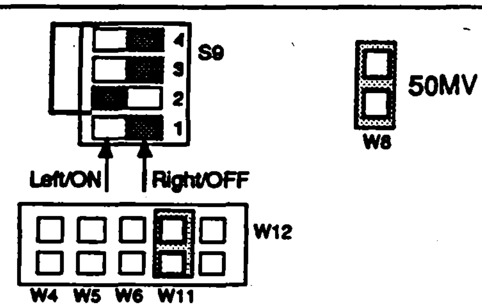
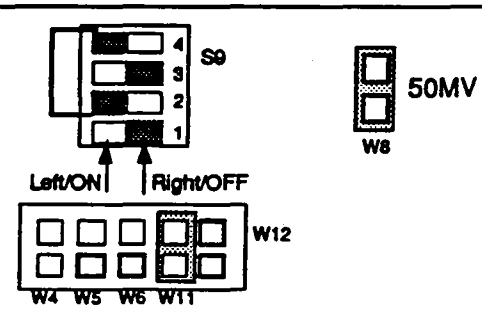
Continued on next page

Table A-1 Summary of DIP Switches and Jumpers, continued

Jumper or DIP-Switch Number	Function	Selections
S9, W4, W6, W7, W8, W9, W11, W12 continued	Select Input actuation type/range with positions 2, 3, and 4; and jumpers.	 Type K thermocouple with upscale burnout  Type T thermocouple with upscale burnout  100 ohm RTD without burnout  4-20 mA without burnout 20947

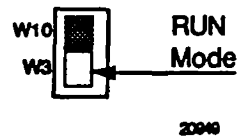
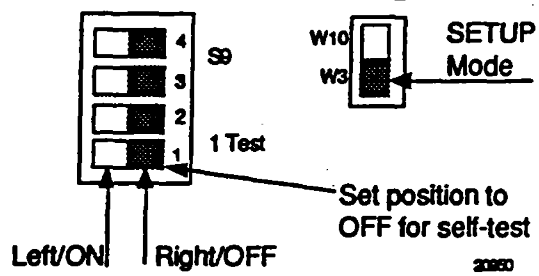
Continued on next page

Table A-1 Summary of DIP Switches and Jumpers, continued

Jumper or DIP-Switch Number	Function	Selections
S9, W4, W6, W7, W8, W9, W11, W12 continued	Select input actuation type/range with positions 2, 3, and 4; and jumpers.	 **0-20 mV without burnout**  **0-50 mV without burnout**  **0-5 Vdc without burnout**  **1-5 Vdc without burnout** 20946

Continued on next page

Table A-1 Summary of DIP Switches and Jumpers, continued

Jumper or DIP-Switch Number	Function	Selections
W3/W10	Select Run Mode.	
W3/W10, S9	Select Set-up mode.	
S1, S2, S3, S4, S5, S6, S7, S8	Set Chart Zero and Full Scale Values.	Refer to *Section 2 - Recording Set-up* for instructions

Appendix B

How to Apply Digital Instrumentation in Severe Electrical Noise Environments

B.1 Overview

Guideline overview

Products that incorporate digital technology provide recognized performance advantages over conventional analog instrumentation used for process control. These advantages can result in better product uniformity and greater overall efficiency when used correctly.

There are, however, certain guidelines regarding installation and wiring which must be carefully followed in order to achieve this performance. In addition to the traditional precaution of the separation of signal and power wiring in separate conduits, other measures must be taken to minimize the effects of electromagnetic interference (EMI) and radio frequency interference (RFI) on the operation of the equipment. Otherwise, if high level, short duration, noise spikes are permitted to enter the digital equipment, the noise can be transferred into the system's logic networks and can be misinterpreted as signal data, resulting in erroneous system operation and other unpredictable responses.

What's in this section

This section contains the following information:

B.2 Potential Noise Sources

Overview

Noise can enter electronic equipment via three methods of coupling, namely:

- Capacitive (or electrostatic)
- Inductive (or magnetic)
- Impedance

Capacitive and inductive coupling

Capacitive and inductive coupling have the same essential effect — they couple current or voltage, without any actual connection of the two circuits. Impedance coupling requires a connection between the two circuits. Typical noise-generating sources that could affect electronic equipment through capacitive and inductive coupling include:

- Relay coils
- Solenoids
- AC power wires — particularly at or above 100 Vac
- Current carrying cables
- Thyristor field exciters
- Radio frequency transmissions

Impedance coupled noise

Impedance-coupled noise may enter by way of the lines used to power the digital equipment or by way of improper grounding. Most power lines, at typical industrial locations, are far from noise-free. The noise on them can be generated in many ways, but are nearly always associated with switching circuits of some nature.

These include:

- Large relays
- Contactors
- Motor starters
- Business and industrial machines
- Power tools
- HID (high-intensity discharge) lights
- Silicon controlled rectifiers (SCRs) that are phase-angled fired

These devices generate noise by lowering the line voltage during energization when large currents are drawn for short periods of time.

B.3 Prevention Methods

Introduction

There are three ways to prevent electrical noise from interfering with the operation of the electronic digital equipment:

- Built-in noise rejection
- Separation of signal and power lines
- Noise suppression at source

Built-in noise rejection

The first method is to design the digital equipment with a high degree of noise rejection built-in. This includes housing the equipment in a case that will provide shielding, liberal use of noise rejection filters and opto-isolators, and the use of noise suppressors on potential noise sources within the equipment itself. This, of course, is the responsibility of the manufacturer who usually performs extensive laboratory and field testing of newly designed digital equipment to insure the adequacy of its immunity to noise. As a minimum requirement, the equipment should be able to pass the tests outlined in the IEEE Standard 472-1974 *(Surge Withstand Capacity Tests)*.

Signal and power line separation

The second method is to prevent noise from getting on the signal and power lines that are connected to the equipment. This is achieved by proper separation and shielding of those lines. In some cases, separate power lines or special power line regulation or filtering may be required for satisfactory electronic digital equipment operation. It is the responsibility of the installer to follow good wiring practices.

Suppression at the source

The third prevention method is to suppress the noise at its source. This is the most effective but also the most difficult because it is not easy to identify all of the potential noise sources in a typical industrial installation. Therefore, "suppression" is usually a last resort for those extreme situations where the other methods are insufficient by themselves. See *Noise Suppression at Source* which follows.

B.4 Recommended Wiring Practices

General rules

- All wiring must conform to local codes and practices.
- Wires carrying similar types of signals (Table B-1) may be bundled together, but bundles with different types of signals must be kept separated to prevent inductive or capacitive coupling.

Wire bundling

Table B-1 shows what wiring should be bundled together to prevent inductive or capacitive coupling.

Table B-1 External Wiring

Wire Function		Bundle No.	Are Shielded Twisted Wires Recommended?
No.	Type		
 1 2 3	HIGH VOLTAGE Line Power Earth Ground Line Voltage Digital I/O	1	NO
 4 5	ANALOG I/O Process Variable RTD Thermocouple dc Millivolts Low level (<100V) 4-20 mA dc 1-5 Vdc	2	YES
 6 7	DIGITAL I/O Low Voltage (<100V) Computer Interface	3	YES

Continued on next page

Additional rules

Please observe these additional rules for wire bundling:

- For distances over five (5) feet, and when shielding is recommended, use a separate metal tray or conduit for each bundle. Where conduits or trays are not practical, use twisted wires with a metal overbraid and provide physical separation of at least one foot.
- Tray covers must be in continuous contact with the side rails of the trays.
- When unlike signal levels must cross, either in trays or conduits, they should cross at a 90-degree angle and at a maximum spacing. Where it is not possible to provide spacing, a grounded steel barrier or grid should be placed between the unlike levels at the crossover points.
- Trays containing low level wiring should have solid bottoms and sides. Tray covers must be used for complete shielding. Tray cover contact with side rails must be positive and continuous to avoid high reluctance air gaps, which impair shielding. Trays for low level cables should be metal and solidly grounded.
- Wires containing low level signals should not be routed near any of the following:
  - Contactors
  - Motors
  - Generators
  - Radio transmitters
  - Wires carrying high current that is being switched on and off
- Use a 12-gage (or heavier) insulated stranded wire for the ground connection. Attach it firmly to a proven good earth ground such as a metal stake driven into the ground.
- All shields should be grounded at one end only — preferably the instrument end.

B.5 Power Source Considerations

Operate within limits

The AC power for the digital electronic equipment must be within the voltage and frequency limits specified for that equipment. Attempts to operate outside the specified limits will result in no performance. For those installations where the supply voltage will not stay within the specified limits, a ferroresonant transformer, for voltage resolution, should be used.

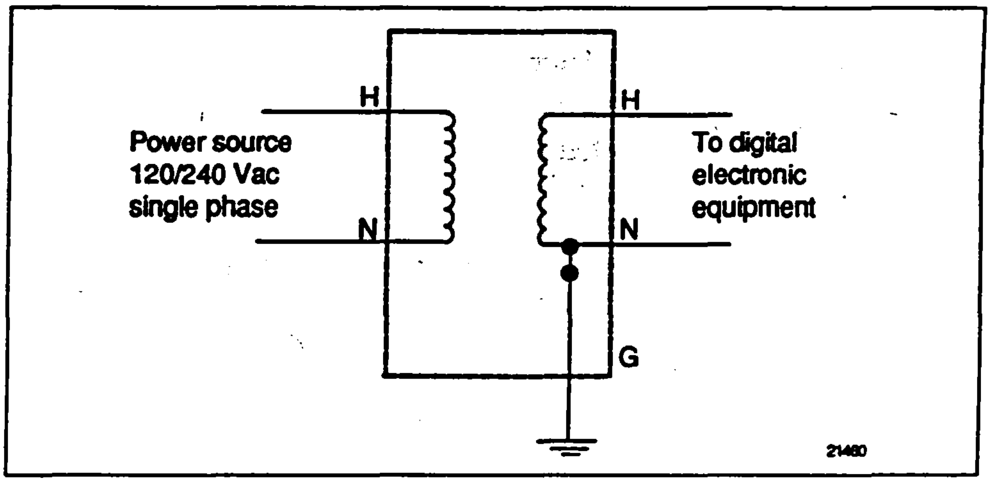
Independent AC source

For protection against noise, the AC source for the digital electronic equipment should be independent of all other loads especially when switching loads are involved. For example, it should not provide power for air-conditioning, convenience outlets, lighting, motors, or similar noise-generating devices. To obtain electrical isolation (see Figure B-1) a separate transformer is required to supply power to the digital equipment. For additional noise and transient rejection, shielded primary and secondary windings may be required. And, if necessary, power line filters may be added to attenuate noise signals that have a higher frequency than the power line frequency.

Transformer for digital equipment

Figure B-1 is an illustration of a separate transformer required to supply power to digital equipment.

Figure B-1 Transformer for Digital Equipment



B.6 Noise Suppression at the Source

Introduction

Generally speaking, when good wiring practices are used with well-designed digital electronic equipment, no further noise protection is necessary. However, in some severe electrical environments, the magnitude of the electrical noise is so great that it must be suppressed at the source. In most control cabinets, the main sources of noise are motor starters, contactors, relays, and switching gear. For this reason, many manufacturers of these devices supply "surge suppressors" which mount directly on the noise source, (for example, on the coil of a control relay or motor starter).

For those devices that do not have accessory "surge suppressors," resistance-capacitance (RC) circuits and/or voltage limiters such as metal varistors may be added when and where needed. This can be broken down into two categories, namely inductive loads (for example, a relay switch in series with a relay coil) and contacts.

Inductive coils

Metal Oxide Varistors (MOVs) are recommended for transient suppression in inductive coils. An MOV is connected in parallel with the coil and is as close as physically possible to the coil (see Figure B-2). MOV devices (listed in Table B-2) are recommended for general purpose applications.

• Table B-2 lists part numbers for recommended MOV devices.

Table B-2 MOV Devices

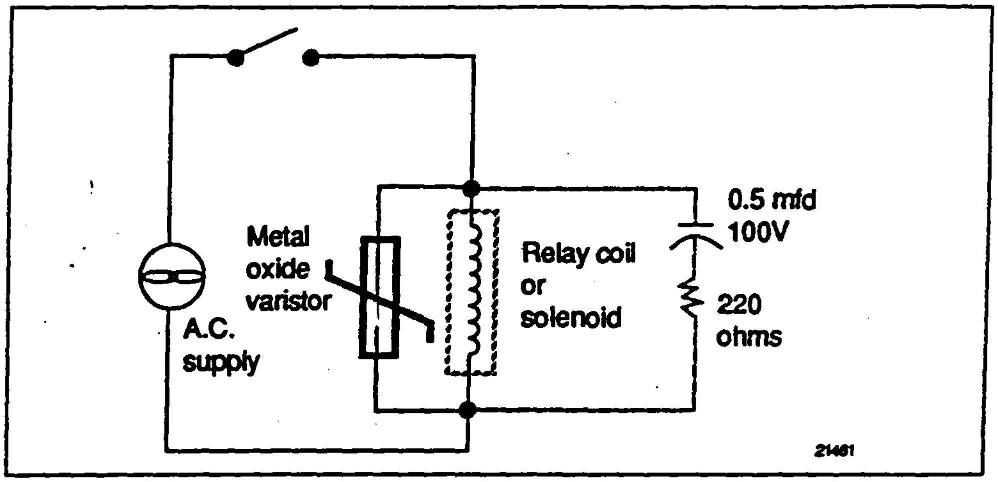
Part Number	30732481-001 *	30732481-002
Maximum AC	130V	275V
Energy Pulse Rating	10 Joules	15 Joules
Supplier (General Electric)	V130LA10A	V275LA15A

Continued on next page

Inductive coils, continued

Figure B-2 is an illustration of transient suppression in inductive coils.

Figure B-2 Transient Suppression in Inductive Coils



Additional protection may be provided by adding an RC circuit in parallel with the MOV. This consists of a 220-ohm resistor in series with a 0.5 microfarad, 1000V capacitor. The power rating of the resistor will depend on the voltage rating of the coil (see Table B-3).

Table B-3 Coil Voltage vs Resistor Voltage Rating

Coil Voltage	Resistor Voltage Rating
115V	1/4 Watt
230V	1 Watt
460V	3 Watt
550V	5 Watt

Continued on next page

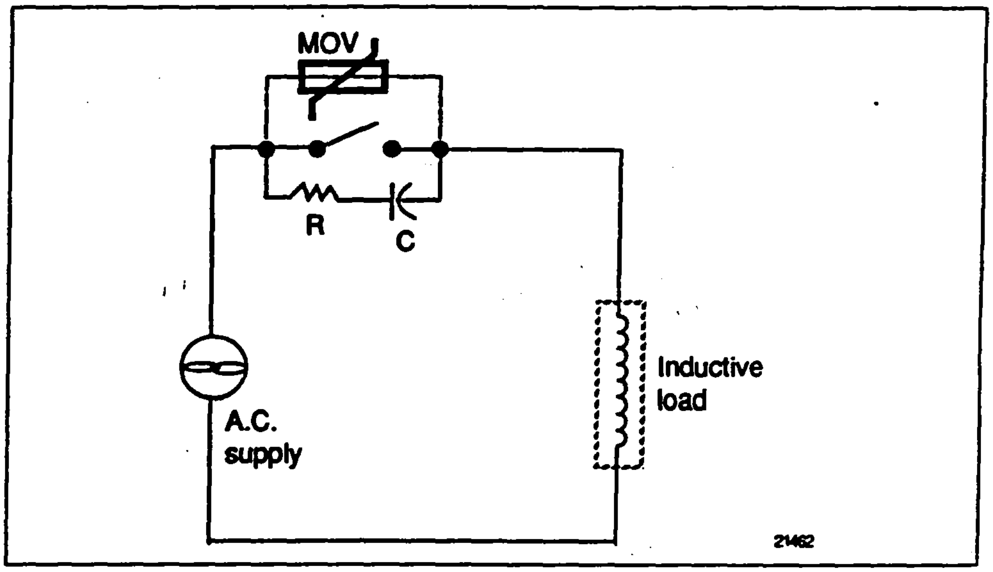
Contacts

When a contact interrupts an inductive load, a certain amount of energy is stored in the load. An MOV or RC circuit in parallel with the load provides a place where this energy may be dissipated. However, if there is no MOV or RC circuit, the energy may create a visible electrical arc across the open contacts. This, in turn, results in electrical noise as well as damage to the contacts.

One way to eliminate this arc is to connect a resistor and capacitor across the contacts (see Figure B-3). A combination of 47 ohms and 0.1 microfarads (1000 Vdc) is recommended for circuits up to 3 amps and 300 Vac. For voltages above 2000 Vac, an MOV across the contact may be added for extra protection.

• Figure B-3 is an illustration of a resistor and capacitor connected across a contact to eliminate electrical noise.

Figure B-3 Contact Noise Suppression



For large load currents, a rule of thumb is to size the capacitor so that the number of microfarads equals the number of amperes in the load current, and the resistor has the same resistance value as the load. The objective is to eliminate the visible arc.

Either discreet resistors and capacitors or packaged RC networks may be used. An RC network (47 ohms and 0.1 microfarad) is available from Honeywell as part number 30371852-001. Similar RC networks are available from Electrocube Inc. (part number RG1782-3) and from Industrial Condensor Corporation.

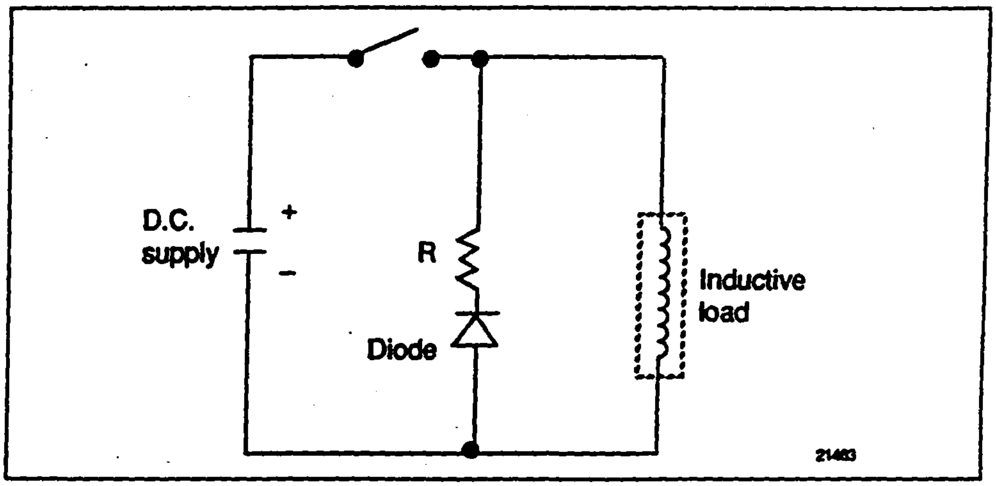
Continued on next page

Contacts, continued

In DC circuits, the power dissipation under steady state condition can be eliminated by placing a diode (in series with a resistor) in parallel with the load (see Figure B-4). The value of R should be less than or equal to the DC resistance of the inductive load.

- Figure B-4 is an illustration of DC load noise suppression.

Figure B-4 DC Load Noise Suppression



Appendix C - Accuracy

C.1 Overview

Rerference accuracy The Reference Accuracy varies according to the type of input actuation.

Table C-1 lists the types of input actuations and their reference accuracy.

These figures include reference junction calibration of ±0.01 degrees using the standard "ice bath" method of calibration. Factory calibration at reference ±1.2 °F. Note that factory calibration may have typical variations of ±150 microvolts or ±0.6 ohms for RTDs which means recalibration may be required to achieve stated accuracy.

Table C-1 Reference Accuracy

Types of Input Actuations	Range		Reference Accuracy*		Temp Stability ± Degrees error Per 1 Degree ΔT
	°F	°C	± °F	± °C	
Thermocouples	0 to 1600	−18 to 871			
J	0 to 1200	−18 to 649	3.5	2.0	0.21
	1200 to 1600	649 to 871	4.5	2.5	0.21
K	−320 to 2500	−196 to 1371			
	−320 to 0	−196 to −18	6.0	3.3	0.70
	0 to 2000	−18 to 1093	5.0	2.8	0.30
	2000 to 2500	1093 to 1371	7.5	4.2	0.40
T	−300 to 700	−184 to 371			
	−300 to −200	−184 to −129	4.5	2.5	0.22
	−200 to 700	−129 to 371	3.0	1.7	0.16
RTD Platinum 100 ohms**	-300 to 900	-184 to 482	3.0	1.7	0.15
Linear Milliamperes dc	0 to 20	—	0.06mA	—	0.011%/°F
	4 to 20	—	0.06mA	—	0.011%/°F
Millivolts dc	0 to 20	—	0.08mV	—	0.011%/°F
	0 to 50	—	0.19mV	—	0.011%/°F
Volts dc	0 to 5	—	0.015V	—	0.011%/°F
	1 to 5	—	0.012V	—	0.011%/°F

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Appendix A

Inspection Documentation

TURNKEY
GAS FIRED
INSPECTIONS / QUALITY CONTROL REPORT
Prior to Shipment

SERIAL #: 9460497

DATE	THERMAL (T) CATALYTIC (C)	TIME	TEST FIRE TEMPERATURES START/OPERATING	DILUTION VALVE (S) OPERABLE	OPERATOR'S SIGNATURE
4/15	T	10:30a	212°F/1413°F		D. [signature]
4/15	C	11:15a	237°F/600°F		D. [signature]

ALARM SHUTDOWN SIMULATIONS / SYSTEM OPERATIONS

ALARM SHUTDOWN SYSTEM OPERATION	DATE	TIME	TEMPERATURE WHEN ALARM ACTIVATED	RESTART TEMPERATURE	OPERATOR'S SIGNATURE
Flame Failure	4/16	10:30a	1413°F	900°F	D. [signature]
Air Failure/ CB*	4/16	10:35a	850°F	730°F	D. [signature]
Air Failure/ PB**	4/16	9:40a	215°F	170°F	D. [signature]
Hi Temp/Shutdown					
Lo Gas Pressure SD***	4/16	8:05a	60°F	60°F	D. [signature]
Hi Gas Pressure SD***	4/16	8:15a	60°F	60°F	D. [signature]
Hi Liquid Level SD***	N/A	N/A	N/A	N/A	N/A
Vacuum Relief Valve	N/A	N/A	N/A	N/A	N/A
KO Pot Pump	N/A	N/A	N/A	N/A	N/A
PB** Amp Load - (see next page)	4/16/97	11:10a	N/A	N/A	D. [signature]
Motor Overloads Set	4/15/97	4:15	N/A	N/A	D. [signature]
Timer 3 Operation Tested	4/16/97	10:50a	N/A	N/A	D. [signature]
Alarm Contacts	4/16/97	10:50a	N/A	N/A	D. [signature]
J1 Tested	4/16/97	10:50a	N/A	N/A	D. [signature]
All Magnehelics Functioning	4/16/97	10:55a	N/A	N/A	D. [signature]
Push to Test Lights	4/16/97	10:30	N/A	N/A	[signature]
Power Interruption	4/16/97	8:30	N/A	N/A	[signature]
PB** enable/disable	N/A	N/A	N/A	N/A	N/A
Temp Ramp Functioning	4/16/97	10:30a	N/A	N/A	D. [signature]
Heat Trace Check	N/A	N/A	N/A	N/A	N/A

*CB = COMBUSTION BLOWER **PB = PROCESS BLOWER ***SD = SHUTDOWN

GROUND FAULT TESTING

The Group Fault Circuit Interrupter (GFCI) used in ThermTech control panels is initially tested, in accordance with UL Subject 508A (Industrial Control Panels), during equipment testing at ThermTech's facility. Once the equipment is installed in the field the GFCI must be tested bimonthly for proper operation, by the operator, and recorded similar to the table below. The components listed below are devices that have been approved by UL for use in this control panel, in conjunction with the GFCI, but have not been evaluated by UL as an individual component, are in the process of being evaluated, or have been approved by another inspection agency (FM for example).

COMPONENT DESIGNATION	COMPONENT MANUFACTURER	CATALOG DESIGNATION	NUMBER USED	PANEL ID	GROUND FAULT TEST DATE
HIGH TEMP CONTROLLER	YOKAGAWA (FM APPROVED)	UT15L*A -or- UT15L*A/RET	1 EACH	T1SH504A	4-16-97
*FLAME INTENSITY METER	HOYT	3125	1 EACH	BI502	4-16-97
*DIGITAL FLOW INDICATOR	TALON	UM3SCL	1 EACH	FI306	N/A
*SIGNAL ISOLATOR	INTERFACE DEVICES	ID4380A	1 EACH	SI	N/A
*TEMPERATURE INDICATOR	OMEGA	BB31K	1 EACH	TI506	N/A

* = This may or may not be included depending on system configuration

PROCESS BLOWER PERFORMANCE

Flow Rate - 100 Scfm
0.06 " w.c. total flow to oxidizer

Amp Draw #1 4.7 A

Vacuum
5 "w.c. at well flange
5 "w.c. at blower
N/A "w.c. Δp across filter
N/A "w.c. total pressure

Motor Horsepower 1 HP
Motor Nameplate Amperage 6.0 A
Motor Service Factor 1.0

Temperature inside noise enclosure N/A °F (if applicable)

-max amp draw on process blower motor
- recirculation valve open enough so air temperature does not exceed 250°F
-enclosure completely assembled.

BLOWER INFORMATION

Brand Rotron
Serial Number 523652
Shop Order Number
Misc. Info

Model Number 610235A B97B
RPM 3450

\\TTK\SYS\APPS\WPDOCS\TESTFIRE\QAGASTK.WCM

INSPECTIONS

ITEM	DATE	INSPECTOR'S SIGNATURE
PRESSURE TEST Gas Train	4-14-97	RG
PAINT	4-16-97	RG
BOLTS, NUTS & SCREWS	4-16-97	RG
BURNER SYSTEM	4/17/97	[signature]
ELECTRICAL SYSTEM	4/17/97	[signature]
GAS TRAIN SYSTEM	4/17/97	[signature]
TRAILER MOUNTING	N/A	N/A

INSPECTIONS APPROVED BY:

MECHANICAL ENGINEERING [signature]
ELECTRICAL ENGINEERING ____________________

READY FOR SHIPMENT:

SALESMAN [signature]

CONFIGURATION/CALIBRATION

9460497

ITEM	DATE	CONFIGURED PROGRAMMED BY:	DATE	CALIBRATION PERFORMED / VERIFIED BY:
TEMPERATURE CONTROLLER	4/15/97	D. [signature]	4/15/97	[signature]
HIGH TEMPERATURE SHUTDOWN CONTROLLER	4/15/97	D. [signature]	4/15/97	[signature]
CONTROL POINT THERMOCOUPLE Type K Range -328°F to 2282°F Temperature Controller Recorder (if applicable)	N/A	N/A	4/15/97	D. [signature]
STACK / CATALYST BED OUTLET THERMOCOUPLE Type K Range -328°F to 2282°F High Temperature Controller Recorder (if applicable) Auto-Dilution Controller (if applicable)	N/A	N/A	4/15/97	D. [signature]
AUTOMATIC DILUTION CONTROLLER (if applicable)	4/15/97	D. [signature]	4/16/97	[signature]
LEL MONITOR (if applicable)	N/A	N/A	N/A	N/A
RECORDER (if applicable) TYPE: DR4200 GP1 Channel configuration: Channel 1 : Temperature 0-1500°F Channel 2 : ________ Channel 3 : ________ Channel 4 : ________ Channel 5 : ________ Channel 6 : ________	4/15/97	D. [signature]	4/15/97	[signature]
RECORDED TEMPERATURE CHANNELS (if applicable) Type K thermocouple -328°F to 2282°F	4/15/97	D. [signature]	4/15/97	[signature]
RECORDED FLOW CHANNELS (if applicable) Transducer type : ________ Range : ________ Process Stream Temperature During Calibration: ________ °F	N/A	N/A	N/A	N/A
TELEMETRY SYSTEM (if applicable)	N/A	N/A	N/A	N/A.

UT 15 E CONFIGURATION **UNIT SERIAL # 9460497**

TEMPERATURE CONTROLLER

THERMAL CONFIGURATION RECORD SHEET

PRESS THE "SET ENT" KEY FOR 3 SECONDS TO ENTER THIS MENU

CODE	PARAMETER	SETTING RANGE
A1	Alarm 1 set point - value 1	140° F
A2	Alarm 2 set point - value 1	1400° F
A3	Alarm 3 set point - value 0	0° F
SC	Super code	ON
AT	Auto - tuning	OFF
P	Proportional Band	0.1
I	Integral time	OFF
D	Derivative time	OFF
P2	Proportional Band	20 *
I2	Integral time	20 *
D2	Derivative time	5 *
MR	Manual Reset	50.0
SP	Setpoint (main)	200°F
SP2	Setpoint (2nd)	1410° F
BS	Measured input bias	0° F

- These tuning values are field adjustable to compensate for temperature fluctuations. Use the auto-tune function of the controller after the unit is up to operating temperature and it will select the optimum tuning values for your process.

\\TTK\SYS\APPS\WPDOCS\TESTFIRE\YUT15E.THR

UT 15L CONFIGURATION **UNIT SERIAL # 9460497**

LIMIT CONTROLLER

THERMAL CONFIGURATION RECORD SHEET

PRESS THE "SET ENT" KEY AND RELEASE TO ENTER THIS MENU

CODE	PARAMETER	SETTING RANGE
OUT	Limit Status	OFF *
TINE	Duration Time	0.0 to 999.9 min **
HI	Maximum of PV	1500 °F
LO	Minumum of PV	0 °F

* This will be **ON** and will have to be reset if the system has shutdown due to high temperature.

** This is the amount of time, in minutes, that the unit was at the maximum PV value.

PRESS THE "SET ENT" KEY FOR 3 SECONDS TO ENTER THIS MENU

SP	Output setpoint	**1500°F**
A1	Alarm 1 setpoint - value __	not used
A2	Alarm 2 setpoint - value __	not used

\\TTK\SYS\APPS\WPDOCS\TESTFIRE\YUT15E.THR

Warranty

ThermTech, Inc. Equipment Warranty

ThermTech will warrant its equipment to be free of defects in material and workmanship for a period of one (1) year from the date of purchase. With regard to components ThermTech, Inc. has purchased and installed on the equipment, that component's manufacturer's expressed warranty will apply. Freight charges, duties, taxes are the customer's responsibility and will not be prepaid by ThermTech, Inc..

The equipment warranty is considered null and void if the equipment is operated beyond the design limitations and/or is modified in any way without written consent of ThermTech, Inc..

8/22/96

Metric Conversion Chart

MULTIPLY	**BY**	**TO OBTAIN**
SCFM	0.02832	m^3/min
ft/sec	0.3048	m/sec
inches of water column	2.54	cm of water column
inches of water column	25.4	mm of water column
inches of water column	2.49	millibars
inches of water column	1.8668	mm of Hg
horsepower	0.746	kilowatts
inches	2.54	cm
inches	25.4	mm
feet	0.3048	m
ft^3	28,317	cm^3
ft^3	0.02832	m^3
pounds	0.45359	kg
PSI	0.0703	kg/cm^2
°C	9/5°C + 32	°F
°F	5/9(°F - 32)	°C

Appendix D

Material Safety Data Sheets

Material Safety Data Sheet

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

Product: CER-WOOL® BLANKET LT, RT, HP, HTA

Internal ID: F009
MSDS No: F009
Date: 6/89
Revision: 1/94

National Paint and Coatings Association

Hazardous Material Identification System

HEALTH HAZARD	2 - See Sections VI and IX for more information.
FLAMMABILITY HAZARD	0 - Minimal
REACTIVITY HAZARD	0 - Minimal
PERSONAL PROTECTION	E - Glasses, gloves and dust respirator.

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: CER-WOOL® BLANKET available as LT, RT, HP, HTA

Description: CER-WOOL® BLANKET is an inorganic, amorphous, glass fiber blanket used for reducing heat transmission through furnace, kiln and vessel structures; an aluminosilicate high temperature insulating material.

CAS# 142844-00-6

Manufacture: Premier Refractories and Chemicals, Inc. **Phone:** 215/337-1100

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name:	CAS Number:	Percent:	Exposure Limits:
Refractory Ceramic Fiber (RCF)	142844-00-6	100	Respirable Dust: 5 mg/m^3 (NIOSH); Total Dust: 10 mg/m^3 (ACGIH TLV-TWA).

Premier Refractories and Chemicals, Inc. recommends an exposure limit of one (1) fiber per cubic centimeter for respirable fiber as an 8-hour time weighted exposure. After-service ceramic fiber may contain crystalline silica in the form of cristobalite. Refer to Section VI for further information. Fiber concentration is determined by time weighted air samples collected and analyzed using NIOSH Method 7400 ("B" counting rules).

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PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

Product: CER-WOOL® BLANKET LT, RT, HP, HTA

Internal ID: F009
MSDS No: F009
Date: 6/89
Revision: 1/94

SECTION III. PHYSICAL DATA

Appearance and Odor: White to off-white, wool type fiber mat, no odor.

Boiling Point: Not Applicable
Vapor Pressure: Not Applicable
Water Solubility (%): 0
Vapor density (air=1): Not Applicable
Evaporation rate: Not Applicable
Specific Gravity: 4-8 lbs/ft^3
Melting Point: >2900°F (1590°C)
% volatile by volume: 0

SECTION IV. FIRE AND EXPLOSION DATA

Extinguishing Media: This refractory insulation product is non-combustible. Use extinguishing media appropriate to the surrounding fire.

Unusual fire or explosion hazards: None

ecial fire-fighting procedures: None

SECTION V. REACTIVITY DATA

This refractory ceramic fiber product is stable under all normal conditions of storage. Hazardous polymerization will not occur.

Chemical incompatibilities: Hydrofluoric Acid

Hazardous decomposition Products: None

SECTION VI. HEALTH HAZARD INFORMATION

Summary of risks: Ceramic fiber can cause eye and skin irritation. Dust from this product contains a respirable fiber and may also contain crystalline silica. A respirator must be worn when exposure limits are exceeded.

Medical conditions which may be aggravated by contact: Dust from the product may aggravate existing chronic lung conditions such as, but not limited to, bronchitis, emphysema, and asthma.

Target organs: Eyes, skin, and respiratory system.

Primary entry route: Inhalation

 HEALTH HAZARD INFORMATION continues on page 3

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

Product: CER-WOOL® BLANKET LT, RT, HP, HTA

Internal ID: F009
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Date: 6/89
Revision: 1/94

HEALTH HAZARD INFORMATION continued from page 2

Acute effects:
Transitory upper respiratory physical irritation. Irritation and inflammation to the eyes on contact and to the skin on prolonged contact.

Chronic effects:
The International Agency for Research on Cancer (IARC) reviewed the carcinogenicity data on man-made vitreous fibers (including RCF) in 1987. IARC classified RCF as possibly carcinogenic to humans (Group 2B). IARC's classification of RCF was based on sufficient evidence of carcinogenicity in experimental animals in the absence of data on the carcinogenicity of RCF to humans. Additionally, IARC classified crystalline silica, which may be found in after-service RCF, as probably carcinogenic to humans (Group 2A).

Signs & symptoms of overexposure:

Eye contact: Physical irritation

Skin contact: Physical irritation

Inhalation: Upper respiratory irritation

First aid:

Eye contact: Flush eyes, including under the eyelids, with large amounts of water. If irritation persists, seek medical attention.

Skin contact: Wash with mild soap and water.

Inhalation: Remove to fresh air.

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures:

Carefully clean-up material into a suitable container, being careful to avoid creating any dust. Clean-up personnel should wear approved respiratory protection, gloves, and goggles to prevent irritation from contact and/or inhalation.

Waste management / Disposal:

This product does not exhibit any characteristics of a hazardous waste. Follow all local, state and federal regulations for proper disposal.

 MSDS F009 continues on page 4

Material Safety Data Sheet

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

Product: CER-WOOL® BLANKET LT, RT, HP, HTA

Internal ID: F009
MSDS No: F009
Date: 6/89
Revision: 1/94

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment: Goggles, gloves, respirators, long sleeve clothing and head covering.

Respiration Protection: Premier Refractories currently recommends an exposure limit of one fiber per cubic centimeter (1 f/cc) for respirable airborne ceramic fiber as an 8-hour time weighted average exposure. Provide workers with NIOSH/MSHA-approved respirators in accordance with requirements of 29 CFR 1910.134 when airborne concentrations of respirable fiber and/or cristobalite exceed the recommended limits.

The following are recommended respirator types for the varying respirable airborne concentrations of ceramic fiber and/or cristobalite.

Fiber	Cristobalite	Respirator Type
< 1 f/cc	< 0.05 mg/m^3	Optional disposable respirator (example: 3M 9900)
1-5 f/cc	0.05-0.5 mg/m^3	Half-mask air-purifying respirator equipped with high-efficiency particulate air (HEPA) filter cartridges (example: 3M 6340).
'5 f/cc	0.5-2.5 mg/m^3	Full-facepiece air-purifying respirator equipped with high-efficiency particulate air (HEPA) filter cartridges (example: 3M 7800 with 7255 filters) or powered air-purifying respirator (PAPR) with HEPA filter cartridges.
>25 f/cc	>2.5 mg/m^3	Any supplied-air respirator operated in positive pressure mode (example: 3M 7800 with W9435 hose and W3196 regulator connected to clean air supply).

Airborne fiber and cristobalite concentrations are determined by time-weighted air samples collected and analyzed using NIOSH Method 7400 ("B" counting rules) and 7500, respectively. Exposures are expressed as 8-hour time weighted averages.

Pending results of long-term health effects studies, engineering controls (i.e. ventilation) and work practices should be established to control levels of airborne fiber to the lowest level attainable.

SAFE HANDLING PROCEDURES FOR WORKING WITH REFRACTORY CERAMIC FIBER PRODUCTS

1. Provide engineering controls where feasible to reduce airborne fiber concentrations to the lowest attainable level.
2. Use NIOSH/MSHA-approved respirators per the above exposure guidelines.
3. Wash exposed clothing to prevent it from becoming laden with dust. Use of disposable work clothing is preferred.
4 Wash exposed skin surfaces with mild soap and water after handling.
5. Refrain from smoking, eating or drinking in refractory ceramic fiber work areas.
6 Minimize accumulation of debris by cleaning up materials which fall to ground as soon as possible.
7 Refrain from dry sweeping and use of compressed air for cleaning. HEPA-filtered vacuuming is the preferred method for waste removal. When HEPA equipment is not available, wet sweeping methods should be used.

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Material Safety Data Sheet

PREMIER REFRACTORIES AND CHEMICALS, INC.
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KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

Product: CER-WOOL® BLANKET LT, RT, HP, HTA

Internal ID: F009
MSDS No: F009
Date: 6/89
Revision: 1/94

SECTION IX. SPECIAL PRECAUTIONS

Further Precautions:
Product which has been in service above 1650°F (900°C) may undergo partial conversion to cristobalite, a form of crystalline silica which presents a health hazard if inhaled over long periods of time. Cristobalite is classified as a probable human carcinogen by IARC, Group 2A.

AFTER-SERVICE RCF REMOVAL PRECAUTIONS:
1. EMPLOYEES SHOULD BE APPRISED OF THE HAZARDS AND PROPER CONDITIONS AND PRECAUTIONS FOR SAFE USE OR EXPOSURE.
2. NIOSH-approved respirators, in accordance with requirements of 29CFR 1910.134 should be used according to the above guidelines for dust levels above the OSHA PEL (8-hour TWA) of 0.05 mg/m^3 for cristobalite.
3. Dust generation should be minimized by the use of dust control equipment or water spray when feasible.
4. Wear protective clothing and vacuum clean prior to removing clothing.
5. Where there is a possibility of exposure to dust containing crystalline silica, the following warning should be posted: FREE SILICA WORK AREA - AVOID BREATHING DUST - DUST MAY CAUSE DELAYED LUNG INJURY (SILICOSIS).

SARA TITLE III INFORMATION:
This product does not contain any substances reportable under SARA TITLE III Sections 302, 304, and 313.

TSCA INVENTORY:
All substances contained in this product are listed in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory.

DOT Class: Not Regulated

Data Source Code(s): 1,7,31,55,85,86,87,89

SECTION X. ACRONYMS/DEFINITIONS USED IN THIS MSDS

ACGIH:	American Conference of Governmental Industrial Hygienists
CAS#:	CAS Registration Number is an assigned number to identify a material. CAS stands for Chemical Abstracts Service.
f/cc:	Fibers per cubic centimeter
HMIS™:	Hazardous Materials Identification System (National Paint & Coatings Association)
IARC:	International Agency for Research on Cancer
MSHA:	Mine Safety and Health Administration
mg/m^3:	Milligrams per cubic meter
NIOSH:	National Institute for Occupational Safety and Health
NFPA:	National Fire Protection Association
OSHA:	Occupational Safety and Health Administration
PEL:	Permissible Exposure Limit (OSHA)
RCF:	Refractory Ceramic Fiber
REL:	Recommended Exposure Limit (NIOSH)

ACRONYMS/DEFINITIONS continues on page 6

Material Safety Data Sheet

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

Product: CER-WOOL® BLANKET LT, RT, HP, HTA

Internal ID: F009
MSDS No: F009
Date: 6/89
Revision: 1/94

ACRONYMS/DEFINITIONS continued from page 5

SARA:	Superfund Amendments and Reauthorization Act
TITLE III:	Emergency Planning and Community Right To Know Act
Section 302:	Extremely Hazardous Substances
Section 304:	Emergency Release
Section 313:	Toxic Chemicals
TLV:	Threshold Limit Values (ACGIH)
TWA:	Time Weighted Average
29CFR1910.134:	OSHA Respiratory Protection Standard

Prepared/revised by: A.G.Nighswander
January 10, 1994

Material Safety Data Sheet

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

Product: CER-WOOL® RIGIDIZER

Internal ID: F026

MSDS No: F026
Revision of: 6/89
Date: November, 1991

National Paint and Coatings Association

Hazardous Material Identification System

HEALTH HAZARD	1 - See Section VI for more information.
FLAMMABILITY HAZARD	0 - Minimal
REACTIVITY HAZARD	0 - Minimal
PERSONAL PROTECTION	E - Glasses, gloves long sleeve clothing.

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: CER-WOOL® RIGIDIZER

Description: CER-WOOL® RIGIDIZER is a colloidal silica mixture used to improve the surface hardness characteristics of the ceramic fiber lining and its resistance to erosion. It can be applied by brushing, dipping or spraying.

CAS# Mixture

Manufacture: Premier Refractories and Chemicals, Inc. **Phone:** 215/337-1100

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name:	CAS Number:	Percent:	Exposure Limits:
Silicate Binder	112926-00-8	10-25	OSHA Final Limits: TWA = 6 mg/m^3; ACGIH TLV:TWA= 10 mg/m^3.
Ethylene Glycol	107-21-1	0-2	OSHA Final Limits: Ceiling= 50 PPM, 125 mg/m^3.
Water	7732-18-5	70-80	None Established
Other Nonhazardous Proprietary Ingredients (each less than 1%).	---------	0-3	None Established

SECTION III. PHYSICAL DATA

Appearance and Odor: Bluish to off-white liquid; odorless.

Boiling Point: 212°F (100°C)
Vapor Pressure: Not Applicable
Water Solubility (%): 1-3
Vapor density (air=1): Not Applicable
pH of solution: 9-9.5

Evaporation rate: Not Applicable
Specific Gravity: 9-10 lbs/gallon
Melting Point: Not Applicable
% volatile by volume: 70-80% Water

 MSDS F026 continues on page 2

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

SECTION IV. FIRE AND EXPLOSION DATA

Extinguishing Media: This product is non-combustible. Use extinguishing media appropriate to the surrounding fire.

The product contains a small amount of ethylene glycol which will emit acrid smoke and toxic fumes when heated to decomposition. Fire fighters must wear self-contained breathing apparatus (SCBA) for fires which engulf large quantities of the product.

SECTION V. REACTIVITY DATA

This product is stable under all normal conditions of storage. Hazardous polymerization will not occur. Product is air-setting, keep in closed containers until ready to use and reseal partially used containers.

Hazardous decomposition Products: Steam, and possibly some ethylene glycol vapors or toxic fumes.

SECTION VI. HEALTH HAZARD INFORMATION

Summary of risks: Dust or mist from the product may contain ethylene glycol and/or amorphous silica.

Medical conditions which may be aggravated by contact: Dust from the product may aggravate existing chronic lung conditions such as, but not limited to, bronchitis, emphysema, and asthma.

Target organs: Eyes, skin, and respiratory system.

Primary entry route: Inhalation

Acute effects: Transitory upper respiratory physical irritation. Irritation and inflammation to the eyes on contact and to the skin on prolonged contact.

Chronic effects: Dust generated from this product may contain a trace of crystalline silica the International Agency for Research on Cancer (IARC) has classified respirable crystalline silica as probably carcinogenic to humans (Group 2A).

Signs & symptoms of overexposure:

Eye contact: Caustic or physical Irritation

Skin contact: Caustic or physical Irritation

Inhalation: Upper respiratory irritation

 HEALTH HAZARD INFORMATION continues on page 3

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety, MSDS Info 215/337-1100

Product: CER-WOOL® RIGIDIZER

Internal ID: F026

MSDS No. / F026
Revision: 6/89
Date: November, 1991

HEALTH HAZARD INFORMATION continued from page 2

First aid:

Eye contact: Flush eyes, including under the eyelids, with large amounts of water. If irritation persists, seek medical attention.

Skin contact: Wash with mild soap and water.

Inhalation: Remove to fresh air.

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures: Carefully clean-up material into a suitable container, being careful to avoid creating any dust from the dried material. If condition warrant clean-up personnel should wear approved respiratory protection, gloves, and goggles to prevent irritation from contact and/or inhalation.

Waste management / Disposal: This product does not exhibit any characteristics of a hazardous waste. Follow all local, state and federal regulations for proper disposal.

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment: Goggles, gloves and long sleeve clothing.

Workplace considerations:

Ventilation: Provide adequate general ventilation and local ventilation to control smoke, fumes and dust levels below the TLV/PEL. This is especially important during initial burn-in of the product.

SECTION IX. SPECIAL PRECAUTIONS

Further Precautions or Information:

SARA TITLE III INFORMATION:
This product does not contain any substances reportable under SARA TITLE III Sections 302, 304, and 313.

TSCA INVENTORY:
All substances contained in this product are listed in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory.

DOT Class: Not Regulated

Data Source Code(s): 1,7,31,55,85,86,87

 MSDS F026 continues on page 4

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

Product: CER-WOOL® RIGIDIZER

Internal ID: F026

MSDS No. F026
Revision: 6/89
Date: November, 1991

SECTION X. ACRONYMS/DEFINITIONS USED IN THIS MSDS

ACGIH:	American Conference of Governmental Industrial Hygienists
CAS#:	CAS Registration Number is an assigned number to identify a material. CAS stands for Chemical Abstracts Service.
IARC:	International Agency for Research on Cancer
SARA:	Superfund Amendments and Reauthorization Act
TITLE III:	Emergency Planning and Community Right To Know Act
Section 302:	Extremely Hazardous Substances
Section 304:	Emergency Release
Section 313:	Toxic Chemicals
TLV:	Threshold Limit Values (ACGIH)
TWA:	Time Weighted Average
29CFR1910.134:	OSHA Respiratory Protection Standard
mg/m^3:	Milligrams per cubic meter
NIOSH:	National Institute for Occupational Safety and Health
NFPA:	National Fire Protection Association
OSHA:	Occupational Safety and Health Administration
PEL:	Permissible Exposure Limit (OSHA)

Prepared/revised by: A.G.Nighswander
November 26, 1991

Material Safety Data Sheet

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

Product: CER-WOOL® ROLLBOARD

Internal ID: F020

MSDS No: F020
Revision of: 6/89
Date: November, 1991

National Paint and Coatings Association

Hazardous Material Identification System

HEALTH HAZARD	2 - See Sections VI and IX for more information.
FLAMMABILITY HAZARD	0 - Minimal
REACTIVITY HAZARD	0 - Minimal
PERSONAL PROTECTION	E - Glasses, gloves and dust respirator.

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: CER-WOOL® ROLLBOARD

Description: CER-WOOL® ROLLBOARD is an inorganic, amorphous, aluminosilicate glass fiber and binder compressed into a flexible rollboard shape, used primarily for its high insulating value and resistance to most chemical attack; a high temperature insulating material.

CAS# Mixture, Inorganic Glass and Binders

Distributor: Premier Refractories and Chemicals, Inc. **Phone:** 215/337-1100

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name:	**CAS Number:**	**Percent:**	**Exposure Limits:**
Refractory Ceramic Fiber (RCF)	Non-assigned	90-100	Respirable Dust: 5 mg/m^3 (NIOSH); Total Dust: 10 mg/m^3 (ACGIH TLV-TWA).
Acrylic Latex Binder	Non-assigned	0-10	None Established

Premier Refractories and Chemicals, Inc. recommends an exposure limit of one (1) fiber per cubic centimeter for respirable fiber as an 8-hour time weighted exposure. After-service ceramic fiber may contain crystalline silica in the form of cristobalite. Refer to Section VI for further information. Fiber concentration is determined by time weighted air samples collected and analyzed using NIOSH Method 7400 ("B" counting rules).

 MSDS F020 continues on page 2

Material Safety Data Sheet

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

Product: CER-WOOL® ROLLBOARD

Internal ID: F020

MSDS No: F020
Revision of: 6/89
Date: November, 1991

SECTION III. PHYSICAL DATA

Appearance and Odor: Off-white flexible, thin board; odorless.

Boiling Point: Not Applicable
Vapor Pressure: Not Applicable
Water Solubility (%): 0
Vapor density (air=1): Not Applicable
Evaporation rate: Not Applicable
Specific Gravity: 8-10 lbs/ft^3
Melting Point: >2900°F (1590°C)
% volatile by volume: 0

SECTION IV. FIRE AND EXPLOSION DATA

Extinguishing Media: This refractory insulation product is non-combustible. However, the binder contained in the product will produce CO, CO_2, and oxides of nitrogen when the product is first exposed to high temperature or flame. Water spray, ABC dry powder and protein type air foams are effective for fires involving large amounts of the product that has not been exposed to high temperature or flames.

Unusual fire or explosion hazards: None

Special fire-fighting procedures: None

SECTION V. REACTIVITY DATA

This refractory ceramic fiber product is stable under all normal conditions of storage. Hazardous polymerization will not occur.

Chemical incompatibilities: Hydrofluoric acid to fiber and nitric acid to the latex binder.

Hazardous decomposition Products: None

SECTION VI. HEALTH HAZARD INFORMATION

Summary of risks: Ceramic fiber can cause eye and skin irritation. Dust from this product contains a respirable fiber and may also contain crystalline silica. A respirator must be worn when exposure limits are exceeded.

Medical conditions which may be aggravated by contact: Dust from the product may aggravate existing chronic lung conditions such as, but not limited to, bronchitis, emphysema, and asthma.

Target organs: Eyes, skin, and respiratory system.

Primary entry route: Inhalation

 HEALTH HAZARD INFORMATION continues on page 3

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety, MSDS Info 215/337-1100

Product: CER-WOOL® ROLLBOARD

Internal ID: F020

MSDS No. / F020
Revision of: 6/89
Date: November, 1991

HEALTH HAZARD INFORMATION continued from page 2

Acute effects:
Transitory upper respiratory physical irritation. Irritation and inflammation to the eyes on contact and to the skin on prolonged contact.

Chronic effects:
The International Agency for Research on Cancer (IARC) reviewed the carcinogenicity data on man-made vitreous fibers (including RCF) in 1987. IARC classified RCF as possibly carcinogenic to humans (Group 2B). IARC's classification of RCF was based on sufficient evidence of carcinogenicity in experimental animals in the absence of data on the carcinogenicity of RCF to humans. Additionally, IARC classified crystalline silica, which may be found in after-service RCF, as probably carcinogenic to humans (Group 2A).

Signs & symptoms of overexposure:

Eye contact: Physical irritation

Skin contact: Physical irritation

Inhalation: Upper respiratory irritation

First aid:

Eye contact: Flush eyes, including under the eyelids, with large amounts of water. If irritation persists, seek medical attention.

Skin contact: Wash with mild soap and water.

Inhalation: Remove to fresh air.

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures:

Carefully clean-up material into a suitable container, being careful to avoid creating any dust. Clean-up personnel should wear approved respiratory protection, gloves, and goggles to prevent irritation from contact and/or inhalation.

Waste management / Disposal:

This product does not exhibit any characteristics of a hazardous waste. Follow all local, state and federal regulations for proper disposal.

MSDS F020 continues on page 4

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

Product: CER-WOOL® ROLLBOARD

Internal ID: F020

MSDS No. / F020
Revision: 6/89
Date: November, 1991

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment: Goggles, gloves, respirators, long sleeve clothing and head covering.

Respiration Protection: Premier Refractories currently recommends an exposure limit of one fiber per cubic centimeter (1 f/cc) for respirable airborne ceramic fiber as an 8-hour time weighted average exposure. Provide workers with NIOSH/MSHA-approved respirators in accordance with requirements of 29 CFR 1910.134 when airborne concentrations of respirable fiber and/or cristobalite exceed the recommended limits.

The following are recommended respirator types for the varying respirable airborne concentrations of ceramic fiber and/or cristobalite.

Fiber	Cristobalite	Respirator Type
< 1 f/cc	< 0.05 mg/m^3	Optional disposable respirator (example: 3M 9900)
1-5 f/cc	0.05-0.5 mg/m^3	Half-mask air-purifying respirator equipped with high-efficiency particulate air (HEPA) filter cartridges (example: 3M 6340).
5-25 f/cc	0.5-2.5 mg/m^3	Full-facepiece air-purifying respirator equipped with high-efficiency particulate air (HEPA) filter cartridges (example: 3M 7800 with 7255 filters) or powered air-purifying respirator (PAPR) with HEPA filter cartridges.
>25 f/cc	>2.5 mg/m^3	Any supplied-air respirator operated in positive pressure mode (example: 3M 7800 with W9435 hose and W3196 regulator connected to clean air supply).

Airborne fiber and cristobalite concentrations are determined by time-weighted air samples collected and analyzed using NIOSH Method 7400 ("B" counting rules) and 7500, respectively. Exposures are expressed as 8-hour time weighted averages.

Pending results of long-term health effects studies, engineering controls (i.e. ventilation) and work practices should be established to control levels of airborne fiber to the lowest level attainable.

SAFE HANDLING PROCEDURES FOR WORKING WITH REFRACTORY CERAMIC FIBER PRODUCTS

1. Provide engineering controls where feasible to reduce airborne fiber concentrations to the lowest attainable level.
2. Use NIOSH/MSHA-approved respirators per the above exposure guidelines.
3. Wash exposed clothing to prevent it from becoming laden with dust. Use of disposable work clothing is preferred.
4 Wash exposed skin surfaces with mild soap and water after handling.
5. Refrain from smoking, eating or drinking in refractory ceramic fiber work areas.
6 Minimize accumulation of debris by cleaning up materials which fall to ground as soon as possible.
7. Refrain from dry sweeping and use of compressed air for cleaning. HEPA-filtered vacuuming is the preferred method for waste removal. When HEPA equipment is not available, wet sweeping methods should be used.

 MSDS F020 continues on page 5

Material Safety Data Sheet

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-1100

Product: CER-WOOL® ROLLBOARD

Internal ID: F020

MSDS No. / F020
Revision of: 6/89
Date: November, 1991

SECTION IX. SPECIAL PRECAUTIONS

Further Precautions:
Product which has been in service above 1650°F (900°C) may undergo partial conversion to cristobalite, a form of crystalline silica which presents a health hazard if inhaled over long periods of time. Cristobalite is classified as a probable human carcinogen by IARC, Group 2A.

AFTER-SERVICE RCF REMOVAL PRECAUTIONS:
1. EMPLOYEES SHOULD BE APPRISED OF THE HAZARDS AND PROPER CONDITIONS AND PRECAUTIONS FOR SAFE USE OR EXPOSURE.
2. NIOSH-approved respirators, in accordance with requirements of 29CFR 1910.134 should be used according to the above guidelines for dust levels above the OSHA PEL (8-hour TWA) of 0.05 mg/m^3 for cristobalite.
3. Dust generation should be minimized by the use of dust control equipment or water spray when feasible.
4. Wear protective clothing and vacuum clean prior to removing clothing.
5. Where there is a possibility of exposure to dust containing crystalline silica, the following warning should be posted: FREE SILICA WORK AREA - AVOID BREATHING DUST - DUST MAY CAUSE DELAYED LUNG INJURY (SILICOSIS).

SARA TITLE III INFORMATION:
This product does not contain any substances reportable under SARA TITLE III Sections 302, 304, and 313.

TSCA INVENTORY:
All substances contained in this product are listed in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory.

DOT Class: Not Regulated
Data Source Code(s): 1,7,31,55,85,86,87,89

SECTION X. ACRONYMS/DEFINITIONS USED IN THIS MSDS

ACGIH:	American Conference of Governmental Industrial Hygienists
CAS#:	CAS Registration Number is an assigned number to identify a material. CAS stands for Chemical Abstracts Service.
f/cc:	Fibers per cubic centimeter
HMIS™:	Hazardous Materials Identification System (National Paint & Coatings Association)
IARC:	International Agency for Research on Cancer
MSHA:	Mine Safety and Health Administration
mg/m^3:	Milligrams per cubic meter
NIOSH:	National Institute for Occupational Safety and Health
NFPA:	National Fire Protection Association
OSHA:	Occupational Safety and Health Administration
PEL:	Permissible Exposure Limit (OSHA)
RCF:	Refractory Ceramic Fiber
REL:	Recommended Exposure Limit (NIOSH)

 ACRONYMS/DEFINITIONS continues on page 6

PREMIER REFRACTORIES AND CHEMICALS, INC.
901 EAST EIGHTH AVENUE, P.O.BOX 1569
KING OF PRUSSIA, PA 19406
Phone: Health, Safety and MSDS Info 215/337-100

ACRONYMS/DEFINITIONS continued from page 5

SARA:	Superfund Amendments and Reauthorization Act
TITLE III:	Emergency Planning and Community Right To Know Act
Section 302:	Extremely Hazardous Substances
Section 304:	Emergency Release
Section 313:	Toxic Chemicals
TLV:	Threshold Limit Values (ACGIH)
TWA:	Time Weighted Average
29CFR1910.134:	OSHA Respiratory Protection Standard

Prepared/revised by: A.G.Nighswander
November 21, 1991

OPERATIONS AND MAINTENANCE MANUAL
MULTIPHASE RECOVERY SYSTEM
FUEL FARM 216
NAS CORPUS CHRISTI, TEXAS

ATTACHMENT 12

SCALE PREVENTION AND DISPERSANT CHEMICALS AND PUMPS (P-4 AND P-5)

SETTINGS FOR CHEMICAL METERING PUMPS (P-4 AND P-5)

For Dynacool 8301-D Dispersant (55 gallon drum), set pump on:

Speed:	5%
Stroke:	50%

For NALCO 8357 Scale Inhibitor (smaller drum), set pump on:

Speed:	4%
Stroke:	30%

Make adjustments to settings only when pumps are in operaton.

C-8357

Cooling Water Chemicals

Product Bulletin

NALCO

NALCO® 8357

MULTIFUNCTIONAL SCALE INHIBITOR AND DISPERSANT FOR ONCE-THROUGH COOLING SYSTEMS

Product Benefits

- NALCO 8357 can help you.
  - —Reduce equipment replacement costs
  - —Reduce operating costs
  - —Reduce cleaning costs
  - —Eliminate costly unscheduled shutdowns
  - —Reduce maintenance costs
- Calcium carbonate scale control
- Silt deposit control
- General dispersancy of suspended particles
- Soluble iron and manganese stabilization

Principal Uses

NALCO 8357 is designed to provide scale, deposit, and fouling control in once-through cooling water systems. It is particularly suited for inhibiting calcium carbonate and calcium sulfate scales, and for dispersing suspended solids such as silt. Do not use in potable drinking water systems.

General Description

NALCO 8357 is a liquid product containing organic polymers with the following characteristics:

Color	Clear to light straw
Odor	None
Density	10.2 lb/gal
pH (Neat)	4.6
Viscosity (@ 60°F)	51 cp
Freeze Point	20°F
Flash Point (PMCC)	>210°F
Freeze-Thaw Recovery	Inactive salt precipitates

Dosage

The specific dosage of NALCO 8357 will vary depending upon the operating characteristics of the system, the water chemistry, and the severity of problems encountered. Your Nalco representative can recommend the optimum dosage necessary to ensure maximum program performance.

Feeding

NALCO 8357 should be fed neat to the system where rapid mixing and distribution will occur, such as the suction side of a pump. Polyolefin, fiberglass, plastic, or rubber may be used in feeding equipment. A 316 stainless steel quill may be necessary; however, no other stainless steel and no mild steel should be used in the system.

Shipping

NALCO 8357 is shipped from Chicago, Illinois, in 55-gallon lined steel drums. Net weight is 565 pounds.

Freight classification: Z

(Continued on Reverse Side)

NALCO CHEMICAL COMPANY
WATER TREATMENT CHEMICALS
1601 WEST DIEHL ROAD □ NAPERVILLE, ILLINOIS 60566

SUBSIDIARIES IN ARGENTINA, AUSTRIA, BRAZIL, CHILE, COLOMBIA, ECUADOR, FINLAND, FRANCE, HOLLAND, HONG KONG, ITALY, JAPAN, PHILIPPINES, SAUDI ARABIA, SPAIN, SWEDEN, VENEZUELA, AND WEST GERMANY • AFFILIATES IN AUSTRALIA, CANADA, MEXICO, SINGAPORE, SOUTH AFRICA, TAIWAN, UNITED KINGDOM, AND THE UNITED STATES

 Printed in U.S.A. 3-85

NALCO

Handling and Storage

NALCO 8357 is acidic and may cause eye and skin irritation. Avoid contact with skin, eyes, and clothing. Do not take internally. Use rubber gloves, goggles, and rubber apron. In case of contact, flush with water for 15 minutes and seek medical attention.

MATERIAL SAFETY DATA SHEET

NALCO

PRODUCT

NALCO 8357 SCALE INHIBITOR

Emergency Telephone Number

Medical (800) 462-5378 (24 hours) **(800) I-M-ALERT**

SECTION 1 PRODUCT IDENTIFICATION

TRADE NAME: NALCO 8357 SCALE INHIBITOR
DESCRIPTION: An aqueous solution of a polyacrylate

NFPA 704M/HMIS RATING: 1/1 HEALTH 1/1 FLAMMABILITY 0/0 REACTIVITY 0 OTHER
0=Insignificant 1=Slight 2=Moderate 3=High 4=Extreme

SECTION 2 HAZARDOUS INGREDIENTS

Our hazard evaluation of the ingredient(s) under OSHA's Hazard Communication Rule, 29 CFR 1910.1200 has found none of the ingredient(s) hazardous.

SECTION 3 PRECAUTIONARY LABEL INFORMATION

CAUTION: May cause irritation to skin and eyes. Avoid contact with skin, eyes and clothing. Do not take internally.

Empty containers may contain residual product. Do not reuse container unless properly reconditioned.

SECTION 4 FIRST AID INFORMATION

EYES: Flush with water for 15 minutes. Call a physician.
SKIN: Flush with water for 15 minutes.
INGESTION: Do not induce vomiting. Give water. Call a physician.
INHALATION: Remove to fresh air. Treat symptoms. Call a physician.

NOTE TO PHYSICIAN: Based on the individual reactions of the patient, the physician's judgment should be used to control symptoms and clinical condition.

CAUTION: If unconscious, having trouble breathing or in convulsions, do not induce vomiting or give water.

SECTION 5 HEALTH EFFECTS INFORMATION

PRIMARY ROUTE(S) OF EXPOSURE: Eye, Skin

EYE CONTACT: May cause irritation with prolonged contact.
SKIN CONTACT: May cause irritation with prolonged contact.

SYMPTOMS OF EXPOSURE: A review of available data does not identify any symptoms from exposure not previously mentioned.

AGGRAVATION OF EXISTING CONDITIONS: A review of available data does not identify any worsening of existing conditions.

SECTION 6 TOXICOLOGY INFORMATION

ACUTE TOXICITY STUDIES: Acute toxicity studies have been conducted on this product. The results are shown below.

ACUTE ORAL TOXICITY (ALBINO RATS): LD50 = Greater than 5,000 mg/kg

ACUTE DERMAL TOXICITY (ALBINO RABBITS): LD50 = Greater than 2,000 mg/kg

PRIMARY SKIN IRRITATION TEST (ALBINO RABBITS):
SKIN IRRITATION INDEX DRAIZE RATING: 0.0/8.0 Non-irritating

PRIMARY EYE IRRITATION TEST (ALBINO RABBITS):
EYE IRRITATION INDEX DRAIZE RATING: 2.7/110.0 Minimally irritating

HUMAN HAZARD CHARACTERIZATION: Based on our hazard characterization, the potential human hazard is: LOW

SECTION 7 PHYSICAL AND CHEMICAL PROPERTIES

COLOR: Clear water-white FORM: Liquid ODOR: Organic

DENSITY:	10.2 lbs/gal.	
SOLUBILITY IN WATER:	Completely	
SPECIFIC GRAVITY:	1.21 - 1.23 @ 60 Degrees F	ASTM D-1298
pH (NEAT) =	3.6 - 4.0	ASTM E-70
VISCOSITY:	51 cps @ 60 Degrees F	ASTM D-2983
FREEZE POINT:	20 Degrees F	ASTM D-1177
FLASH POINT:	None (PMCC)	ASTM D-93
VOLATILE ORGANIC COMPOUND (VOC):	0.3 lbs/gal.	EPA METHOD 24

NOTE: These physical properties are typical values for this product.

SECTION 8 FIRE AND EXPLOSION INFORMATION

FLASH POINT: None (PMCC) ASTM D-93

EXTINGUISHING MEDIA: This product would not be expected to burn unless all the water is boiled away. The remaining organics may be ignitable. Use water to cool containers exposed to fire.

UNUSUAL FIRE AND EXPLOSION HAZARD: May evolve NOx under fire conditions. Containers exposed in a fire should be cooled with water to prevent vapor pressure buildup leading to a rupture.

MATERIAL SAFETY DATA SHEET

NALCO

PRODUCT

NALCO 8357 SCALE INHIBITOR

Emergency Telephone Number

Medical (800) 462-5378 (24 hours) **(800) I-M-ALERT**

SECTION 9 REACTIVITY INFORMATION

INCOMPATIBILITY: Avoid contact with strong oxidizers (eg. chlorine, peroxides, chromates, nitric acid, perchlorates, concentrated oxygen, permanganates) which can generate heat, fires, explosions and the release of toxic fumes.
THERMAL DECOMPOSITION PRODUCTS: In the event of combustion CO, CO_2, NOx may be formed. Do not breathe smoke or fumes. Wear suitable protective equipment.

SECTION 10 PERSONAL PROTECTION EQUIPMENT

RESPIRATORY PROTECTION: Respiratory protection is not normally needed since the volatility and toxicity are low. If significant vapors, mists or aerosols are generated, wear a NIOSH approved or equivalent respirator.

For large spills, entry into large tanks, vessels or enclosed small spaces with inadequate ventilation, a positive pressure, self-contained breathing apparatus is recommended.

VENTILATION: General ventilation is recommended.

ROTECTIVE EQUIPMENT: Use impermeable gloves and chemical splash goggles when attaching feeding equipment or doing maintenance.

The availability of an eye wash fountain and safety shower is recommended.

If clothing is contaminated, remove clothing and thoroughly wash the affected area. Launder contaminated clothing before reuse.

HUMAN EXPOSURE CHARACTERIZATION: Based on Nalco's recommended product application and our recommended personal protective equipment, the potential human exposure is: MODERATE.

SECTION 11 SPILL AND DISPOSAL INFORMATION

IN CASE OF TRANSPORTATION ACCIDENTS, CALL THE FOLLOWING 24-HOUR TELEPHONE NUMBER (800) I-M-ALERT or (800) 462-5378.

SPILL CONTROL AND RECOVERY:

Small liquid spills: Contain with absorbent material, such as clay, soil or any commercially available absorbent. Shovel reclaimed liquid and absorbent into recovery or salvage drums for disposal. Refer to CERCLA in Section 14.

Large liquid spills: Dike to prevent further movement and reclaim into recovery or salvage drums or tank truck for disposal. Refer to CERCLA in Section 14.

SECTION 11 SPILL AND DISPOSAL INFORMATION (CONTINUED)

DISPOSAL: If this product becomes a waste, it does not meet the criteria of a hazardous waste as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, nor is it listed under Subpart D.

As a non-hazardous liquid waste, it should be solidified with stabilizing agents (such as sand, fly ash, or cement) so that no free liquid remains before disposal to an industrial waste landfill. A non-hazardous liquid waste can also be incinerated in accordance with local, state and federal regulations.

SECTION 12 ENVIRONMENTAL INFORMATION

AQUATIC DATA:

96 hour static acute LC50 to Bluegill Sunfish = Greater than 1,000 ppm

96 hour no observed effect concentration is 1,000 ppm based on no mortality or abnormal effects.

96 hour static acute LC50 to Rainbow Trout = Greater than 1,000 ppm

96 hour no observed effect concentration is 1,000 ppm based on no mortality or abnormal effects.

48 hour static acute LC50 to Daphnia Magna = Greater than 1,000 ppm

48 hour no observed effect concentration is 560 ppm based on no mortality or abnormal effects.

TOXICITY RATING: Essentially non-toxic

96 hour static acute LC50 to Mysid Shrimp = 464 mg/L

TOXICITY RATING: Slightly toxic

96 hour static acute LC50 to Silversides (Menidia beryllina) = Greater than 1,000 mg/L

TOXICITY RATING: Essentially non-toxic

SECTION 12 ENVIRONMENTAL INFORMATION (CONTINUED)

If released into the environment, see CERCLA in Section 14.

ENVIRONMENTAL HAZARD AND EXPOSURE CHARACTERIZATION: Based on our Hazard Characterization, the potential environmental hazard is: LOW.
Based on Nalco's recommended product application and the product's characteristics, the potential environmental exposure is: HIGH.

SECTION 13 TRANSPORTATION INFORMATION

PROPER SHIPPING NAME/HAZARD CLASS MAY VARY BY PACKAGING, PROPERTIES, AND MODE OF TRANSPORTATION. TYPICAL PROPER SHIPPING NAMES FOR THIS PRODUCT ARE:

ALL TRANSPORTATION MODES : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

SECTION 14 REGULATORY INFORMATION

The following regulations apply to this product.

FEDERAL REGULATIONS:

OSHA'S HAZARD COMMUNICATION RULE, 29 CFR 1910.1200:
Based on our hazard evaluation, none of the ingredients in this product are hazardous.

CERCLA, 40 CFR 117, 302:
Notification of spills of this product is not required.

SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 (TITLE III) - SECTIONS 302, 311, 312 AND 313:

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355):
This product does not contain ingredients listed in Appendix A and B as an Extremely Hazardous Substance.

SECTIONS 311 and 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS (40 CFR 370):
Our hazard evaluation has found that this product is not hazardous under 29 CFR 1910.1200.

Under SARA 311 and 312, the EPA has established threshold quantities for the reporting of hazardous chemicals. The current thresholds are: 500 pounds or the threshold planning quantity (TPQ), whichever is lower, for extremely

SECTION 14 REGULATORY INFORMATION (CONTINUED)

hazardous substances and 10,000 pounds for all other hazardous chemicals.

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372):
This product does not contain ingredients on the List of Toxic Chemicals.

TOXIC SUBSTANCES CONTROL ACT (TSCA):
The chemical ingredients in this product are on the 8(b) Inventory List (40 CFR 710).

FOOD AND DRUG ADMINISTRATION (FDA):
Federal Food, Drug and Cosmetic Act:
While this product was not specifically developed for direct use in the papermaking process, when use situations necessitate compliance would be acceptable for use in the manufacture of paper and paperboard used for food contact purposes.

This product has been certified as KOSHER/PAREVE for year-round use INCLUDING HE PASSOVER SEASON by the CHICAGO RABBINICAL COUNSIL.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA), 40 CFR 261 SUBPART C & D:
Consult Section 11 for RCRA classification.

FEDERAL WATER POLLUTION CONTROL ACT, CLEAN WATER ACT, 40 CFR 401.15 (formerly Sec. 307), 40 CFR 116 (formerly Sec. 311):
None of the ingredients are specifically listed.

CLEAN AIR ACT, Sec. 111 (40 CFR 60), Sec. 112 (40 CFR 61, 1990 Amendments),
Sec. 611 (40 CFR 82, CLASS I and II Ozone depleting substances):
This product does not contain ingredients covered by the Clean Air Act.

STATE REGULATIONS:

CALIFORNIA PROPOSITION 65:
This product does not contain any chemicals which require warning under California Proposition 65.

MICHIGAN CRITICAL MATERIALS:
This product does not contain ingredients listed on the Michigan Critical Materials Register.

STATE RIGHT TO KNOW LAWS:
The following ingredient(s) are disclosed for compliance with State Right To Know Laws:

MATERIAL SAFETY DATA SHEET

NALCO

PRODUCT

NALCO 8357 SCALE INHIBITOR

Emergency Telephone Number

Medical (800) 462-5378 (24 hours) **(800) I-M-ALERT**

SECTION 14 REGULATORY INFORMATION (CONTINUED)

Acrylate polymer	Trade secret
Inorganic salts	Trade secrets
Water	7732-18-5

INTERNATIONAL REGULATIONS:

This is not a WHMIS controlled product under The House of Commons of Canada Bill C-70.

SECTION 15 ADDITIONAL INFORMATION

None

SECTION 16 RISK CHARACTERIZATION

Due to our commitment to Product Stewardship, we have evaluated the human and environmental hazards and exposures of this product. Based on our recommended use of this product, we have characterized the product's general risk. This information should provide assistance for your own risk management practices. We have evaluated our product's risk as follows:

* The human risk is: LOW.

* The environmental risk is: LOW.

Any use inconsistent with Nalco's recommendations may affect our risk characterization. Our sales representative will assist you to determine if your product application is consistent with our recommenadtions. Together we can implement an appropriate risk management process.

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to insure safe workplace operations. Please consult your local sales representative for any further information.

SECTION 17 BIBLIOGRAPHY

ANNUAL REPORT ON CARCINOGENS, U.S. Department of Health and Human Services, Public Health Service, PB 33-135855, 1983.

SECTION 17 BIBLIOGRAPHY (CONTINUED)

CASARETT AND DOULL'S TOXICOLOGY, THE BASIC SCIENCE OF POISONS, Doull, J., Klaassen, C. D., and Admur, M. O., eds., Macmillian Publishing Company, Inc., N. Y., 4th edition, 1996.

CHEMICAL HAZARDS OF THE WORKPLACE, Proctor, N. H., and Hughes, J. P., eds., J. P. Lipincott Company, N.Y., 3rd edition, 1991.

DANGEROUS PROPERTIES OF INDUSTRIAL MATERIALS, Sax, N. Irving, ed., Van Nostrand Reinhold Company, N.Y., 9th edition, 1996.

IARC MONOGRAPHS ON THE EVALUATION OF THE CARCINOGENIC RISK OF CHEMICALS TO MAN, Geneva: World Health Organization, International Agency for Research on Cancer.

PATTY'S INDUSTRIAL HYGIENE AND TOXICOLOGY, Clayton, G. D., Clayton, F. E., eds., John Wiley and Sons, N. Y., 4th edition, Vol. 2 A-F, 1994.

GISTRY OF TOXIC EFFECTS ON CHEMICAL SUBSTANCES, U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1983 supplement of 1981-1982 edition, Vol. 1-3, OH, 1984.

Title 29 Code of Federal Regulations Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA).

THRESHOLD LIMIT VALUES FOR CHEMICAL SUBSTANCES AND PHYSICAL AGENTS IN THE WORKROOM ENVIRONMENT WITH INTENDED CHANGES, American Conference of Governmental Industrial Hygienists, OH.

PREPARED BY: William S. Utley, PhD., DABT, Manager, Product Safety
DATE CHANGED: 06/12/95 DATE PRINTED: 10/17/96

Cooling Water Chemicals **Product Bulletin**

C-8301-D

NALCO

DYNACOOL® 8301-D DISPERSANT

Product Benefits

- Excellent calcium phosphate stabilization
- Added iron dispersancy
- Part of the DYNACOOL III stabilized phosphate program:
  —provides excellent corrosion control
  —environmentally acceptable, safer than chromates
  —no heavy metals
  —broad application range
  —less sensitive to system upsets
- Effective dispersant for chromate programs
- Effective dispersant for alkaline treatment programs:
  —A• Z• LITE® — no yellow metal protection
  —Alkaline phosphate

Principal Uses

DYNACOOL 8301-D is designed to disperse and stabilize calcium phosphate and iron in open-recirculating cooling water systems. The product is formulated as the dispersant for the two-part DYNACOOL III stabilized phosphate program for open-recirculating systems.

The stabilized phosphate program is a non-metal program which uses a controlled film of orthophosphate and polyphosphate for corrosion protection. DYNACOOL 8301-D is used in conjunction with another phosphate source in the DYNACOOL III stabilized phosphate program.

The program can be used on a wide variety of make-up waters including those with phosphate contamination.

General Description

DYNACOOL 8301-D is a liquid polymeric dispersant.

For typical chemical and physical properties, refer to the DYNACOOL 8301-D Material Safety Data Sheet.

Dosage and Feeding

DYNACOOL 8301-D dosage depends on recirculating water conditions. Your Nalco representative can help you select the best dosage for your system.

DYNACOOL 8301-D must be fed continuously to assure that adequate levels of chemical residual are maintained at all times. The product should be fed neat through equipment using stainless steel, polyethylene, PVC, or Teflon components. Mild steel is not acceptable.

Handling

Read the label and Material Safety Data Sheet for complete handling information before using this product.

(Continued on Reverse Side)

NALCO CHEMICAL COMPANY
ONE NALCO CENTER ▫ NAPERVILLE, ILLINOIS 60563-1198

Operations in Argentina, Australia, Austria, Belgium, Brazil, Canada, Caribbean, Chile, Colombia, Ecuador, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Indonesia, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, New Zealand, Norway, Peru, Philippines, Portugal, Russia, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Taiwan, Thailand, Turkey, United Kingdom, U.S.A., Venezuela and Yugoslavia.

NALCO

Shipping and Storage

DYNACOOL 8301-D is available in bulk, in 55-gallon nonreturnable drums containing approximately 500 lb net, and in 200- or 400-gallon returnable PORTA-FEED® units.

The product has a suggested storage limit of six months.

Quality

We certify that all received batches of DYNACOOL 8301-D meet or exceed all in process and finished product quality standards set for this product. Certificate of analysis for each batch is available through the Nalco Quality Control Department on the following parameters:

pH
Viscosity
Specific Gravity

Please contact your Nalco representative for more details.

Remarks

If you need assistance or information, please call your nearest Nalco representative, or our Naperville office at (708) 305-1000.

For **Medical and Transportation Emergencies** involving Nalco products call (24-hour response): (800) I-M-ALERT or (800) 462-5378.

MATERIAL SAFETY DATA SHEET

NALCO

PRODUCT

DYNACOOL III 8301D LIQUID

Emergency Telephone Number

Medical (800) 462-5378 (24 hours) **(800) I-M-ALERT**

SECTION 1 PRODUCT IDENTIFICATION

TRADE NAME: DYNACOOL III 8301D LIQUID
DESCRIPTION: An aqueous solution of an acrylic polymer

NFPA 704M/HMIS RATING: 0/0 HEALTH 0/0 FLAMMABILITY 0/0 REACTIVITY 0 OTHER
0=Insignificant 1=Slight 2=Moderate 3=High 4=Extreme

SECTION 2 HAZARDOUS INGREDIENTS

Our hazard evaluation of the ingredient(s) under OSHA's Hazard Communication Rule, 29 CFR 1910.1200 has found none of the ingredient(s) hazardous.

SECTION 3 PRECAUTIONARY LABEL INFORMATION

CAUTION: May cause irritation to skin and eyes. Avoid contact with skin, eyes and clothing. Do not take internally.

Empty containers may contain residual product. Do not reuse container less properly reconditioned.

SECTION 4 FIRST AID INFORMATION

EYES:	Flush with water for 15 minutes. Call a physician.
SKIN:	Flush with water for 15 minutes.
INGESTION:	Do not induce vomiting. Give water. Call a physician.
INHALATION:	Remove to fresh air. Treat symptoms. Call a physician.

NOTE TO PHYSICIAN: Based on the individual reactions of the patient, the physician's judgment should be used to control symptoms and clinical condition.

CAUTION: If unconscious, having trouble breathing or in convulsions, do not induce vomiting or give water.

SECTION 5 HEALTH EFFECTS INFORMATION

PRIMARY ROUTE(S) OF EXPOSURE: Eye, Skin

EYE CONTACT:	May cause irritation with prolonged contact.
SKIN CONTACT:	May cause irritation with prolonged contact.

SYMPTOMS OF EXPOSURE: A review of available data does not identify any symptoms from exposure not previously mentioned.

GRAVATION OF EXISTING CONDITIONS: A review of available data does t identify any worsening of existing conditions.

NALCO

MATERIAL SAFETY DATA SHEET

PRODUCT

DYNACOOL III 8301D LIQUID

Emergency Telephone Number

Medical (800) 462-5378 (24 hours) **(800) I-M-ALERT**

SECTION 6 TOXICOLOGY INFORMATION

TOXICITY STUDIES: Toxicity studies have not been conducted on this product, but acute studies have been conducted on the acrylic polymer. The results are shown below.

ACUTE ORAL TOXICITY (ALBINO RATS):
Acrylic polymer LD50 = Greater than 5,000 mg/kg

PRIMARY SKIN IRRITATION TEST (ALBINO RABBITS): Acrylic polymer
SKIN IRRITATION INDEX DRAIZE RATING: 0.0/8.0 Non-irritating

PRIMARY EYE IRRITATION TEST (ALBINO RABBITS): Acrylic polymer
EYE IRRITATION INDEX DRAIZE RATING: 4.7/110.0 Minimally irritating

HUMAN HAZARD CHARACTERIZATION: Based on our hazard characterization, the potential human hazard is: LOW

SECTION 7 PHYSICAL AND CHEMICAL PROPERTIES

COLOR: Clear colorless to yellow FORM: Liquid ODOR: Ammonia

DENSITY:	8.9-9.3 lbs/gal.	
pH (NEAT) =	4.5-6.0	ASTM E-70
SPECIFIC GRAVITY:	1.07-1.12 @ 77 Degrees F	ASTM D-1298
VISCOSITY:	8 cps @ 70 Degrees F	ASTM D-2983
FREEZE POINT:	28 Degrees F	ASTM D-1177
FLASH POINT:	None (PMCC)	ASTM D-93

NOTE: These physical properties are typical values for this product.

SECTION 8 FIRE AND EXPLOSION INFORMATION

FLASH POINT: None (PMCC) ASTM D-93

EXTINGUISHING MEDIA: Not applicable

UNUSUAL FIRE AND EXPLOSION HAZARD: May evolve NOx and SOx under fire conditions.

SECTION 9 REACTIVITY INFORMATION

INCOMPATIBILITY: None known.

THERMAL DECOMPOSITION PRODUCTS: In the event of combustion CO, CO2, NOx, SOx may be formed. Do not breathe smoke or fumes. Wear suitable protective

SECTION 9 REACTIVITY INFORMATION (CONTINUED)

equipment.

SECTION 10 PERSONAL PROTECTION EQUIPMENT

RESPIRATORY PROTECTION: Respiratory protection is not normally needed.

For large spills, entry into large tanks, vessels or enclosed small spaces with inadequate ventilation, a positive pressure, self-contained breathing apparatus is recommended.

VENTILATION: General ventilation is recommended.

PROTECTIVE EQUIPMENT: Use impermeable gloves and chemical splash goggles when attaching feeding equipment, doing maintenance or handling product. Examples of impermeable gloves available on the market are neoprene, nitrile, PVC, natural rubber, viton and butyl (compatibility studies have not been performed).

e availability of an eye wash fountain and safety shower is recommended.

If clothing is contaminated, remove clothing and thoroughly wash the affected area. Launder contaminated clothing before reuse.

HUMAN EXPOSURE CHARACTERIZATION: Based on Nalco's recommended product application and our recommended personal protective equipment, the potential human exposure is: MODERATE.

SECTION 11 SPILL AND DISPOSAL INFORMATION

IN CASE OF TRANSPORTATION ACCIDENTS, CALL THE FOLLOWING 24-HOUR TELEPHONE NUMBER (800) I-M-ALERT or (800) 462-5378.

SPILL CONTROL AND RECOVERY:

Small liquid spills: Contain with absorbent material, such as clay, soil or any commercially available absorbent. Shovel reclaimed liquid and absorbent into recovery or salvage drums for disposal. Refer to CERCLA in Section 14.

Large liquid spills: Dike to prevent further movement and reclaim into recovery or salvage drums or tank truck for disposal. Refer to CERCLA in Section 14.

DISPOSAL: If this product becomes a waste, it does not meet the criteria of hazardous waste as defined under the Resource Conservation and Recovery Act .CRA) 40 CFR 261, since it does not have the characteristics of Subpart C,

SECTION 11 SPILL AND DISPOSAL INFORMATION (CONTINUED)

nor is it listed under Subpart D.

As a non-hazardous liquid waste, it should be solidified with stabilizing agents (such as sand, fly ash, or cement) so that no free liquid remains before disposal to an industrial waste landfill. A non-hazardous liquid waste can also be incinerated in accordance with local, state and federal regulations.

SECTION 12 ENVIRONMENTAL INFORMATION

BIOCHEMICAL OXYGEN DEMAND (5-day BOD): 1,960 mg/L

CHEMICAL OXYGEN DEMAND (COD): 190,000 mg/L

TOTAL ORGANIC CARBON (TOC): 63,000 mg/L

AQUATIC DATA: Results below are based on the acrylic polymer.

96 hour static acute LC50 to Bluegill Sunfish = Greater than 1,000 ppm

96 hour no observed effect concentration is 1,000 ppm based on no mortality or abnormal effects.

96 hour static acute LC50 to Rainbow Trout = Greater than 1,000 ppm

96 hour no observed effect concentration is 560 ppm based on no mortality or abnormal effects.

48 hour static acute LC50 to Daphnia magna = Greater than 1,000 ppm

48 hour no observed effect concentration is 180 ppm based on no mortality or abnormal effects.

Results below are based on the product.

96 hour static acute LC50 to Mysid shrimp = Greater than 1,000 ppm

96 hour no observed effect concentration is Greater than 1,000 ppm based on no mortality or abnormal effects.

If released into the environment, see CERCLA in Section 14.

ENVIRONMENTAL HAZARD AND EXPOSURE CHARACTERIZATION: Based on our Hazard Characterization, the potential environmental hazard is: LOW.

SECTION 12 ENVIRONMENTAL INFORMATION (CONTINUED)

Based on Nalco's recommended product application and the product's characteristics, the potential environmental exposure is: HIGH.

SECTION 13 TRANSPORTATION INFORMATION

PROPER SHIPPING NAME/HAZARD CLASS MAY VARY BY PACKAGING, PROPERTIES, AND MODE OF TRANSPORTATION. TYPICAL PROPER SHIPPING NAMES FOR THIS PRODUCT ARE:

ALL TRANSPORTATION MODES : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

SECTION 14 REGULATORY INFORMATION

The following regulations apply to this product.

EDERAL REGULATIONS:

OSHA HAZARD COMMUNICATION RULE, 29 CFR 1910.1200:
Based on our hazard evaluation, this product is not hazardous.

CERCLA/SUPERFUND, 40 CFR 117, 302:
Notification of spills of this product is not required.

SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 (TITLE III) - SECTIONS 302, 311, 312 AND 313:

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355):
This product does not contain ingredients listed in Appendix A and B as an Extremely Hazardous Substance.

SECTIONS 311 and 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS (40 CFR 370):
Our hazard evaluation has found that this product is not hazardous under 29 CFR 1910.1200.

Under SARA 311 and 312, the EPA has established threshold quantities for the reporting of hazardous chemicals. The current thresholds are: 500 pounds or the threshold planning quantity (TPQ), whichever is lower, for extremely hazardous substances and 10,000 pounds for all other hazardous chemicals.

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372):
his product does not contain ingredients on the List of Toxic Chemicals.

SECTION 14 REGULATORY INFORMATION (CONTINUED)

TOXIC SUBSTANCES CONTROL ACT (TSCA):
The chemical ingredients in this product are on the 8(b) Inventory List (40 CFR 710).

U. S. DEPARTMENT OF AGRICULTURE (USDA):
USDA Inspection and Grading Programs - Food Safety and Inspection Service:
This product is authorized by USDA for use in federally inspected meat and poultry plants. Authorized use(s) is/are under category G7, for treating boilers, steam lines, and/or cooling systems where neither the treated water nor the steam produced may contact edible products; and G5, for treatment of cooling and retort water.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA), 40 CFR 261 SUBPART C & D:
Consult Section 11 for RCRA classification.

FEDERAL WATER POLLUTION CONTROL ACT, CLEAN WATER ACT, 40 CFR 401.15/ formerly Sec. 307, 40 CFR 116/formerly Sec. 311:
ne of the ingredients are specifically listed.

CLEAN AIR ACT, Sec. 111 (40 CFR 60), Sec. 112 (40 CFR 61, 1990 Amendments), Sec. 611 (40 CFR 82, CLASS I and II Ozone depleting substances):
This product does not contain ingredients covered by the Clean Air Act.

STATE REGULATIONS:

CALIFORNIA PROPOSITION 65:
This product does not contain any chemicals which require warning under California Proposition 65.

MICHIGAN CRITICAL MATERIALS:
This product does not contain ingredients listed on the Michigan Critical Materials Register.

STATE RIGHT TO KNOW LAWS:
The following ingredient(s) are disclosed for compliance with State Right To Know Laws:

Acrylic polymer	Trade secret
Water	7732-18-5

INTERNATIONAL REGULATIONS:

This is not a WHMIS controlled product under The House of Commons of Canada
11 C-70.

NALCO

PRODUCT
DYNACOOL III 8301D LIQUID

Emergency Telephone Number
Medical (800) 462-5378 (24 hours) (800) I-M-ALERT

SECTION 15 ADDITIONAL INFORMATION

Nalco internal numbers 100590 and 100772

SECTION 16 RISK CHARACTERIZATION

Due to our commitment to Product Stewardship, we have evaluated the human and environmental hazards and exposures of this product. Based on our recommended use of this product, we have characterized the product's general risk. This information should provide assistance for your own risk management practices. We have evaluated our product's risk as follows:

* The human risk is: LOW.

* The environmental risk is: LOW.

Any use inconsistent with Nalco's recommendations may affect our risk characterization. Our sales representative will assist you to determine if your product application is consistent with our recommenadtions. Together we can implement an appropriate risk management process.

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to insure safe workplace operations. Please consult your local sales representative for any further information.

SECTION 17 BIBLIOGRAPHY

ANNUAL REPORT ON CARCINOGENS, U.S. Department of Health and Human Services, Public Health Service, PB 33-135855, 1983.

CASARETT AND DOULL'S TOXICOLOGY, THE BASIC SCIENCE OF POISONS, Doull, J., Klaassen, C. D., and Admur, M. O., eds., Macmillian Publishing Company, Inc., N. Y., 4th edition, 1996.

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IARC MONOGRAPHS ON THE EVALUATION OF THE CARCINOGENIC RISK OF CHEMICALS

SECTION 17 BIBLIOGRAPHY (CONTINUED)

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PREPARED BY: William S. Utley, PhD., DABT, Manager, Product Safety
DATE CHANGED: 02/10/93 DATE PRINTED: 10/17/96

ELECTRONIC METERING PUMPS

INSTALLATION
MAINTENANCE
TROUBLESHOOTING

Please record the following data:
(Information on Pump Box and Pump Data Plate)

Pump Model Number: P131-190S
Pump Serial Number: 9705130000
Installation Date: 9/10/97
Installation Location: NAS Corpus Christi

When ordering replacement parts for your LMI Metering Pump or accessory, please include the complete model number and serial number of your unit.

LMI
LIQUID METRONICS DIVISION
MILTON ROY
ISO9001 Certified • a unit of Sundstrand Corporation
8 Post Office Square • Acton, MA 01720 U.S.A.
TEL (508) 263-9800 • FAX (508) 264-9172

Replaces same of Rev. J 8/96
1615.J 12/96

Parts: Pumps + Controls 800-359-7337

CONTENTS

1.0 INTRODUCTION

LMI is the world's most versatile manufacturer of economical and efficient metering pumps. This manual addresses the installation, maintenance and troubleshooting procedures for manually and externally controlled pumps. LMI has a worldwide network of stocking representatives and authorized repair centers to give you prompt and efficient service.

Please review this manual carefully. Pay particular attention to warnings and precautions. Always follow good safety procedures, including the use of proper clothing, eye and face protection.

This manual is for A, B, C, E, J, P Series pumps.

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 65 ACTON, MA

POSTAGE WILL BE PAID BY ADDRESSEE

LMI
LIQUID METRONICS DIVISION
MILTON ROY

LIQUID METRONICS DIVISION, MILTON ROY
8 POST OFFICE SQUARE
ACTON, MA 01720-9848 U.S.A.

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

WARRANTY REGISTRATION INFORMATION

Register our warranty as follows:

Model No. ______________________

Serial No. ______________________

Installation Date ______________________

Company or Organization ______________________

____

Address ______________________

____

City ______________________

State or Province ______________________

ZIP or Postal Code ______________________

Telephone No. ______________________

Fax ______________________

Name of Operator or Responsible Supervisor ______________________

____

Our LMI product is being used for:

___ Waste water treatment

___ Cooling water treatment

___ Boiler water treatment

___ Municipal water treatment

___ Fertilizer injection

___ Laboratory fluid metering

___ Fluoridation

___ Paper chemical feed

___ Domestic potable water

___ Swimming pool or therapy bath

___ Other ______________________

____

The solution we will pump is:

(name or type) ______________________

supplied by (company) ______________________

of (location) ______________________

The concentration as pumped is approximately ______ % by volume

Pressure at the injection point is ± ______ psi kPa bar (circle one)

Pressure at the suction point is ± ______ psi kPa bar (circle one)

I selected this LMI product because of:

______ design features ___ price ___ quality reputation

___ other ______________________

I would like my LMI product better if: ______________________

____

Please send additional information on LMI products to:

Name ______________________

Address ______________________

City ______________________ State ______________________

ZIP or Postal Code ______________________

Telephone No. ______________________

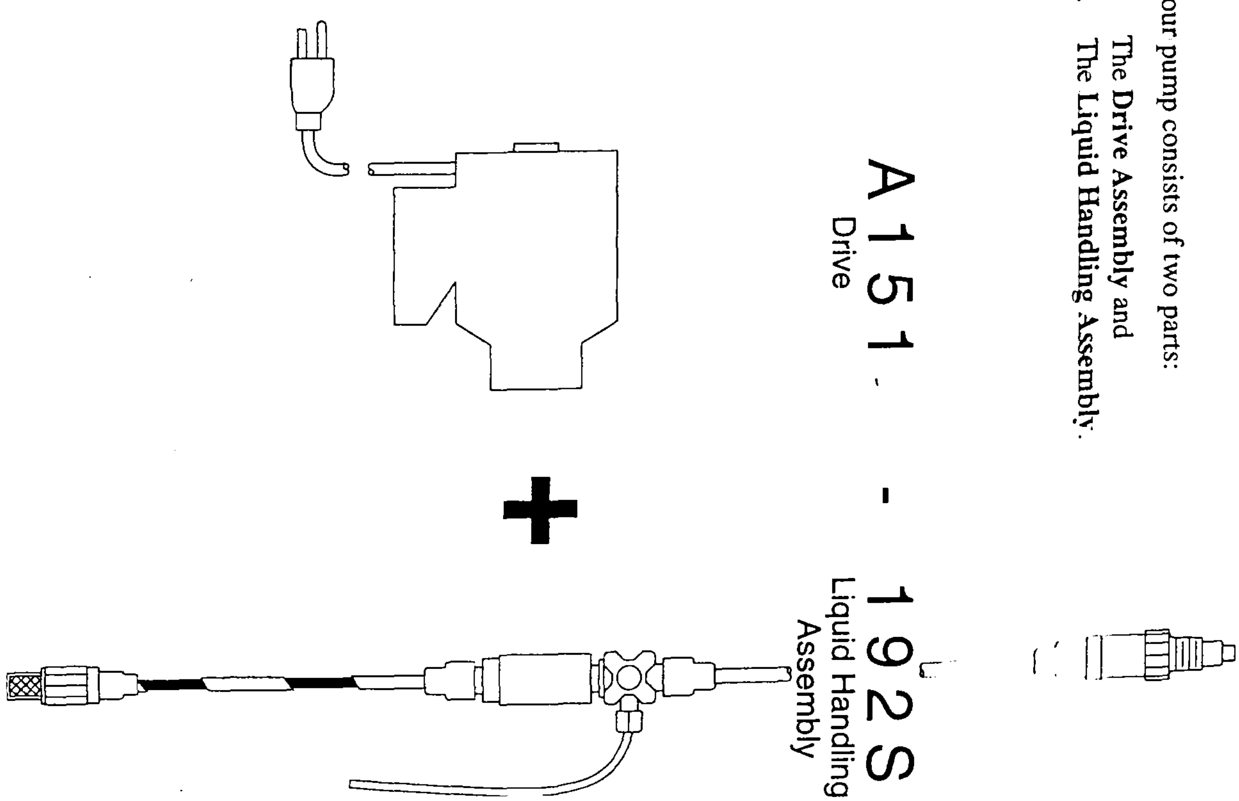
(Separate registration card here and return to LMI)

Your warranty registration card is attached above. Please fill it out and return it to LMI to register your warranty. If your registration card is not attached, please call LMI's Customer Service Group at (508) 263-9800, or fax us at (508) 264-9172.

EXAMPLE:

Your pump consists of two parts:

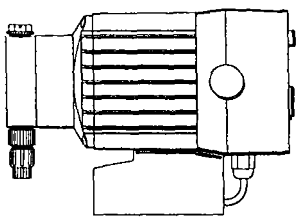
1. The Drive Assembly and
2. The Liquid Handling Assembly.



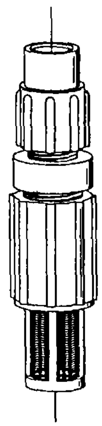
2.0 UNPACKING

Your carton will contain the following items. Please notify the carrier immediately if there are any signs of damage to the pump or its parts. Notify your pump supplier if any of the following parts are missing.

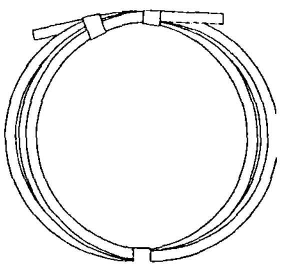
Please refer to the enclosed Drive Assembly Parts List Sheet for an illustration of your complete pump, electrical diagram and a parts list.



Metering Pump

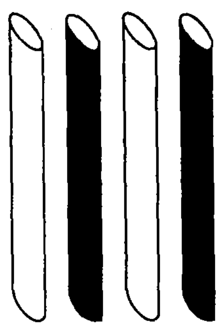


Foot Valve

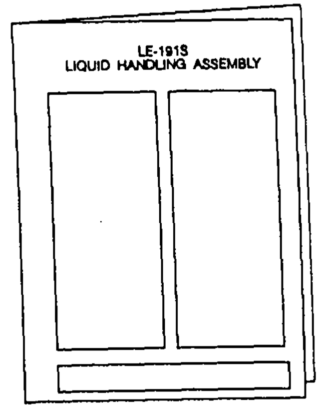


Tubing

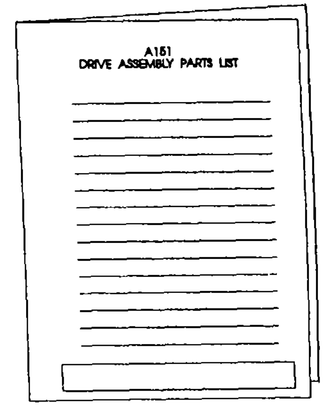
Depending on the model, your carton may contain 0, 1, 2 or 3 rolls of tubing. Your carton may contain an additional roll of clear vinyl tubing, this is for connection to the SUCTION SIDE OF THE PUMP HEAD ONLY.



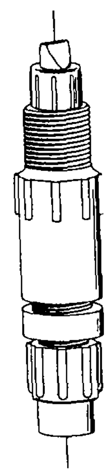
Suction Tubing Straightener



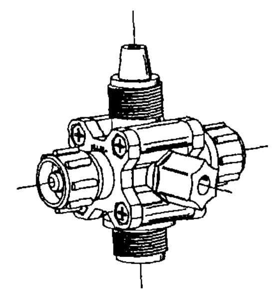
Liquid Handling Assembly Sheet



Drive Assembly Parts List & Exploded View Drawing



Injection Check Valve



FOUR FUNCTION Valve (4-FV) and Tubing

Your carton may or may not contain a 4-FV, an accessory for pump models ending in "M" or "S".

3.0 PRE-INSTALLATION INSTRUCTIONS

The following precautions should be taken when working with LMI metering pumps. Please read this section carefully prior to installation.

3.1 Precautions

Protective Clothing

ALWAYS wear protective clothing, face shield, safety glasses and gloves when working on or near your metering pump. Additional precautions should be taken depending on the solution being pumped. Refer to MSDS precautions from your solution supplier.

Water Pre-Prime

All LMI pumps are pre-primed with water when shipped from the factory. If your solution is not compatible with water, disassemble the Pump Head Assembly. Thoroughly dry the pump head, valves, seal rings, balls and Liquifram® (diaphragm). Re-assemble head assembly tightening screws in a crisscross pattern. Refill the pump head with the solution to be pumped before priming the pump. (This will aid in priming).

Solution Compatibility

Your Liquid Handling Assembly Sheet lists the materials of construction included in the liquid handling portion of your pump. Should you have any further compatibility questions on your LMI Metering Pump, review the **LMI Pump Selection Guide** and **Chemical Resistance Chart** for compatibility. If this sheet is not available to you, call your local LMI distributor, or the LMI Customer Service Department for further information.

Tubing Connections

Inlet and outlet tubing or pipe sizes must not be reduced. Make certain that all tubing is SECURELY ATTACHED to fittings prior to start-up. (See Section 4.3, Tubing Connections). ALWAYS use LMI supplied tubing with your pump, as the tubing is specifically designed for maximum compatibility with the pump operation. It is recommended that all tubing be shielded to prevent possible injury in case of rupture or accidental damage.

Fittings And Machine Threads

All fittings should be hand tightened to a maximum of 1/8 - 1/4 turn after the fitting contacts the seal ring. DO NOT OVERTIGHTEN FITTINGS. Overtightening or use of a pipe wrench can cause damage to the fittings, seal rings, or pump head, causing the pump to LOSE PRIME OR NOT FUNCTION.

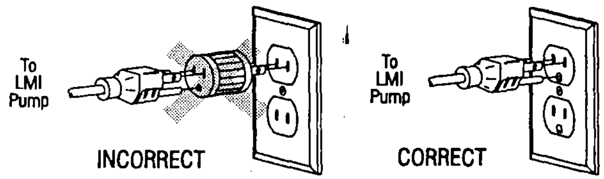
All LMI pumps have straight 3/4"-16 or 1"-12 machine threads on the head and fittings and are sealed by the seal rings. DO NOT use Teflon tape or pipe dope to seal threads. <u>Teflon Tape may only be used on the 1/2" NPT thread side of the Injection Check Valve</u> before installing in a pipe line or tee.

Plumbing

Always adhere to your local plumbing codes and requirements. Be sure installation does not constitute a cross connection. Check local plumbing codes for guidelines. LMI is not responsible for improper installations.

Electrical Connections

WARNING: to reduce the risk of electrical shock, the metering pump must be plugged into a grounded outlet with ratings conforming to the data on the pump control panel. The pump must be connected to a good ground. **DO NOT USE ADAPTERS!** All wiring must conform to local electrical codes.



4.0 INSTALLATION

4.1 Pump Location and Installation

Locate pump in an area convenient to solution tank and electrical supply.

The pump should be accessible for routine maintenance, and should not be subjected to ambient temperatures above 122°F (50°C). If the pump will be exposed to direct sunlight, LMI black, UV resistant tubing should be installed.

4.2 Pump Mounting

The pump can be mounted in one of two ways:

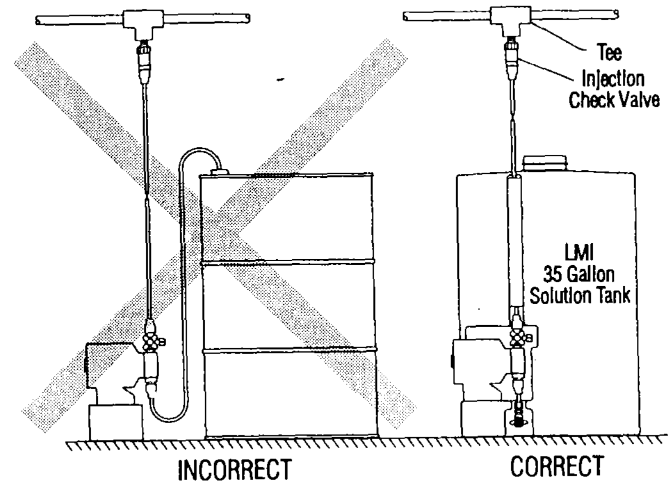
A. **FLOODED SUCTION** (ideal installation) or

B. **SUCTION LIFT** - when suction lift is less than 5 feet (1.5 m) for solutions having a specific gravity of water. For denser solutions, consult the factory.

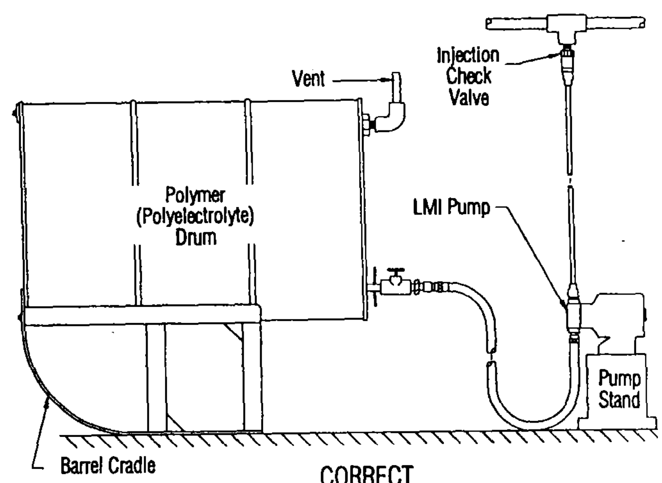
Your LMI metering pump must be mounted so that the suction and discharge valves are vertical. **NEVER position pump head and fittings horizontally.**

4.2A Flooded Suction

The pump is mounted at the base of the storage tank. This installation is the most trouble-free, and is recommended for very low outputs, solutions that gasify, and high viscosity solutions. Since the suction tubing is filled with solution, priming is accomplished quickly and the chance of losing prime is reduced.

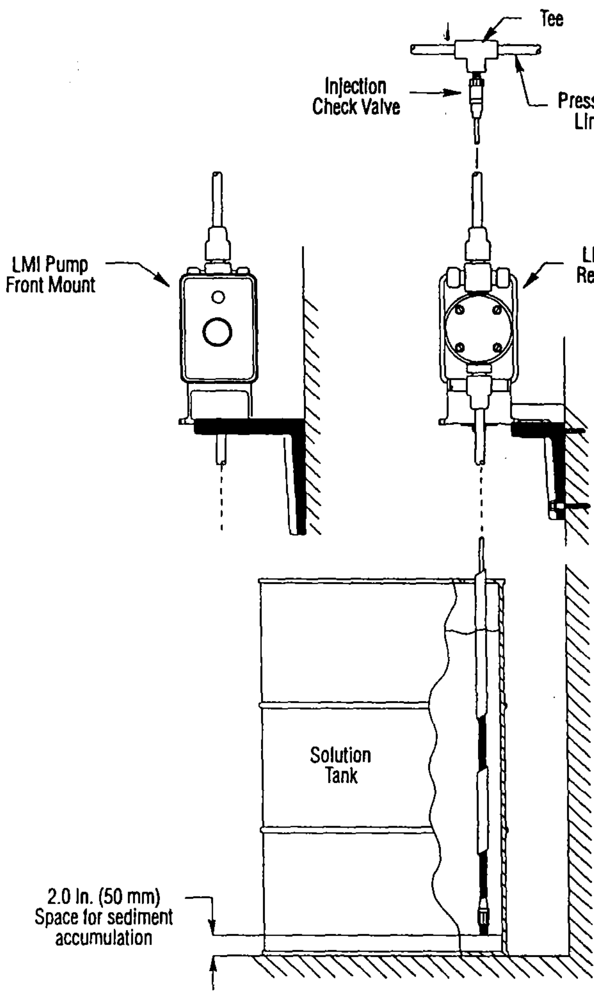


Avoid this type of false flooded suction.



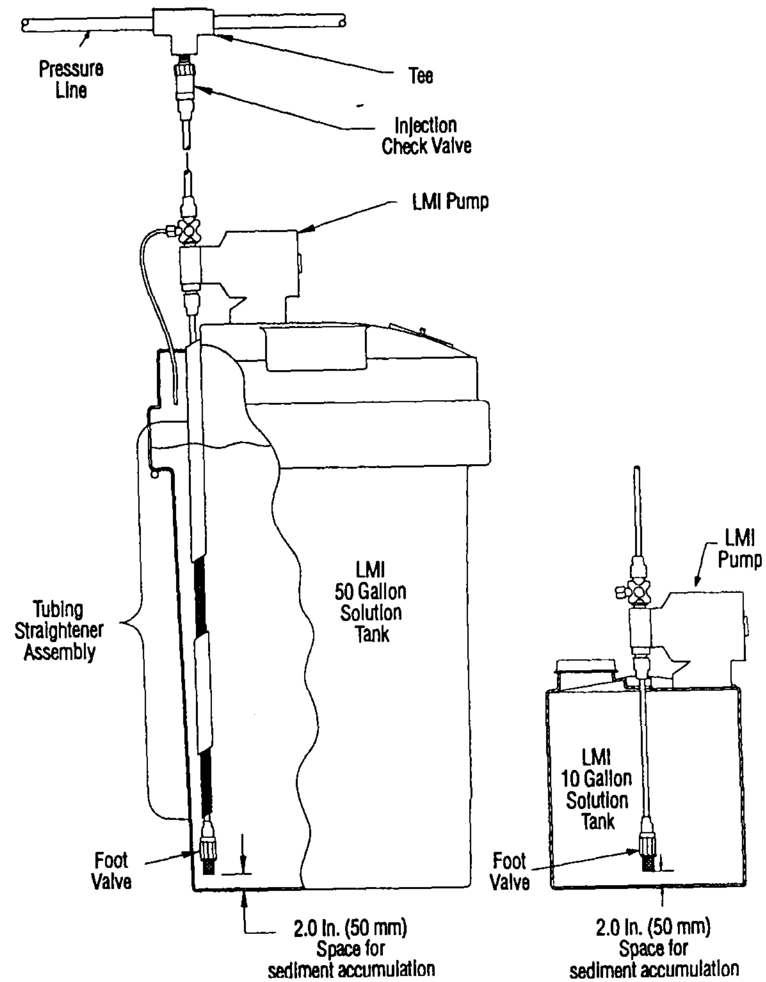
4.2B1 Suction Lift - Wall Bracket Mount

The pump may be mounted using an LMI Wall Mount Bracket Assembly (part no. 34643) directly above the solution tank. A pump mounted in this manner allows for easy changing of solution tanks or drums.



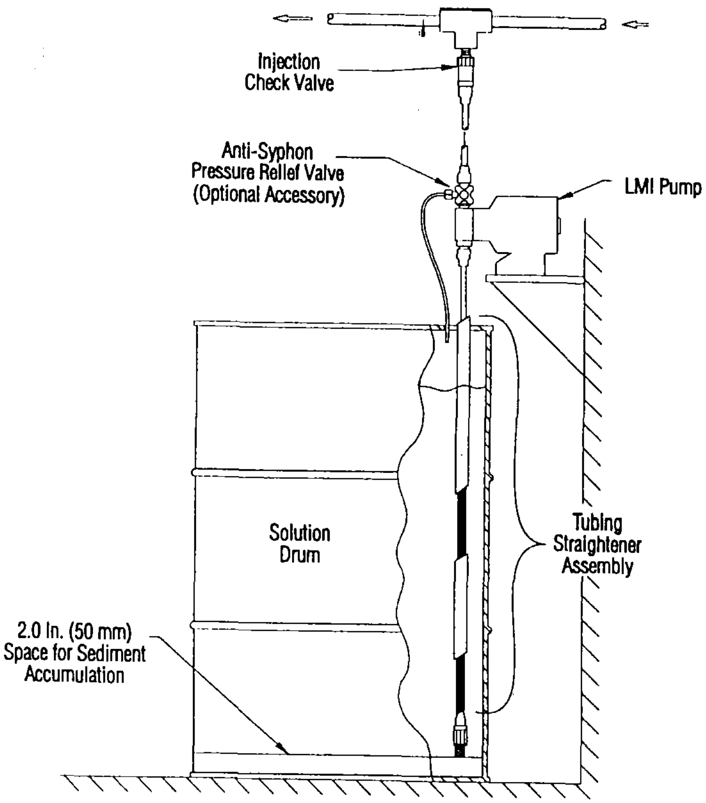
4.2B2 Suction Lift - Tank Mount

The pump may be mounted on a molded tank provided there is a recess to keep pump stationary. LMI 10 gallon tanks (part no. 27421) and 50 gallon tanks (part no. 26350) have molded recesses for pump mounting.



4.2B3 Suction - Shelf Mount

The pump may be mounted on a shelf (customer supplied) maintaining a suction lift of less than 5 feet (1.5 m). An LMI mounting kit (part number 10461) is available for securing the pump to a shelf.



4.3 Tubing Connections

A. Use only LMI tubing.

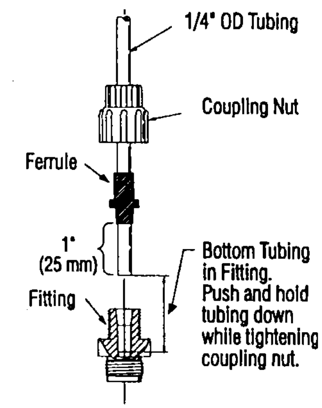
B. **DO NOT USE CLEAR VINYL TUBING ON THE DISCHARGE SIDE OF THE PUMP.** The pressure created by the pump can rupture the vinyl tubing.

C. Before installation, all tubing must be cut with a clean square end.

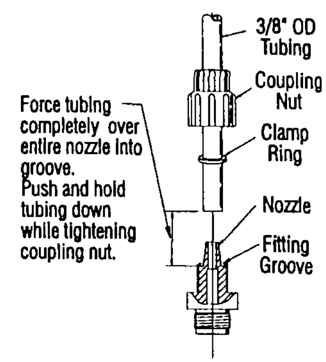
D. Valve and head connections from the factory are capped or plugged to retain pre-prime water. Remove and discard these caps or plugs before connecting tubing.

DO NOT USE PLIERS OR PIPE WRENCH ON COUPLING NUTS OR FITTINGS.

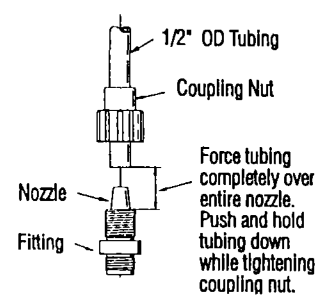
Tubing Connection 1/4" O.D. (.250") Tubing



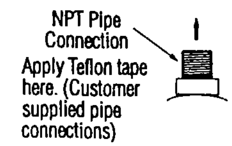
Tubing Connection 3/8" O.D. (.375") Tubing



Tubing Connection 1/2" O.D. (.5") Tubing



1/4" or 1/2" NPT Pipe Thread Connection



NOTE: See Metric Liquid Handling Sheet for metric tubing connections.

4.4 Four Function Valve (4-FV)

Some pump models come supplied with a 4-FV (pump models which end in "M"or"S"). If your pump is not equipped with this feature, and you feel it is needed in your application, it can be purchased as an accessory. Contact your local distributor for ordering information. The functions of the 4-FV are:

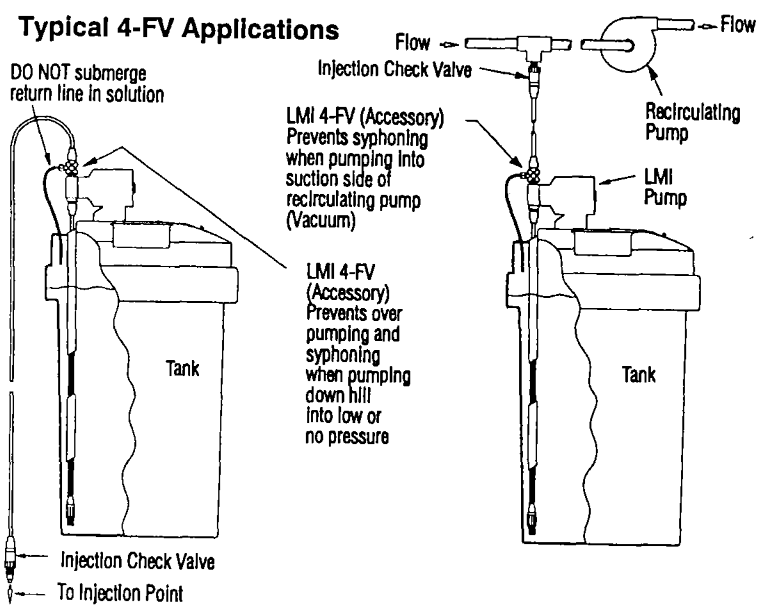
1. Anti-Syphon (automatic).
Prevents syphoning when pumping downhill or into a vacuum.

2. Back Pressure (automatic).
Supplies approximately 25 psi back pressure to prevent over pumping when little or no system back pressure is present.

3. Pressure Relief (automatic).
If discharge line is overpressurized, the valve opens sending the solution back to your supply tank.

4. Line Depressurization (manual).
By pulling both knobs, the discharge line will drain back to your supply tank.

Typical 4-FV Applications



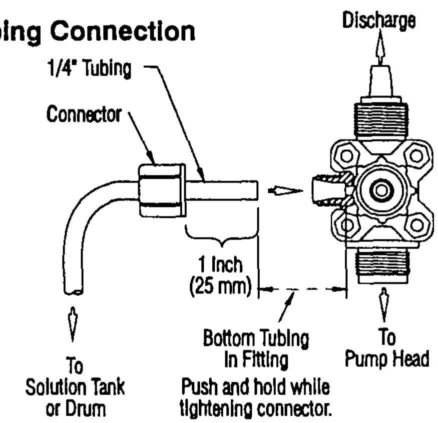
4.5 4-FV Installation

To install the 4-FV, remove the yellow screw cap on the top of the pump head and screw in the 4-FV so that the valve contacts the seal ring. An additional 1/8 - 1/4 turn may be necessary to prevent leakage. **DO NOT OVERTIGHTEN.** Overtightening can cause fittings and seal rings to distort, crack and function improperly.

1/4" O.D. tubing connects to the side of the 4-FV and acts as a return line to the solution tank. This tubing must **NOT** be submerged in the solution.

WARNING: This return line tubing must be secured to insure pumped solution will return to supply tank.

4-FV Tubing Connection



4.6 Foot Valve/Suction Tubing Straightener Installation

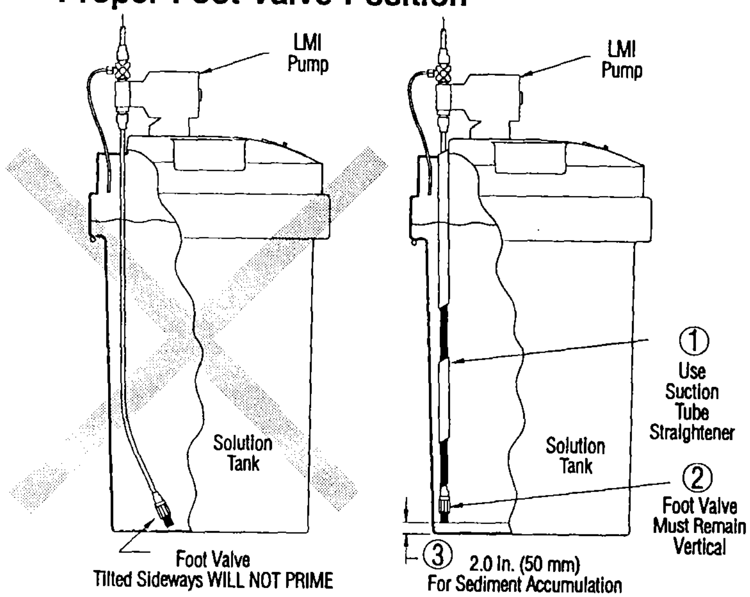
The Foot Valve acts as a check valve to keep the pump primed in suction lift applications.

The valve is designed to be submersed in the solution tank or drum and must sit in a vertical position at the bottom. Position approximately 2 inches (50 mm) off the bottom if the tank or drum contains sediment.

The suction tubing straightener, when assembled, positions the foot valve and suction tubing in a vertical position.

1. Attach the foot valve to one end of the suction tubing (see Tubing Connections, section 4.3).
2. Assemble the suction tubing straightener by pushing together alternating yellow and black tubes. Adjust the length of the tubing straightener by pushing tubes further together so when placed over the suction tubing and sitting on the foot valve, approximately 3 inches (75 mm) of tubing exits the tubing straightener on the side to be connected to the pump.
3. Place foot valve, tubing and suction tubing straightener into the solution tank. Check that the foot valve is vertical and approximately 2 inches (50 mm) from the bottom of the tank or drum (see illustration). Connect the other end of the tubing to the suction side of the pump head (bottom side).

Proper Foot Valve Position



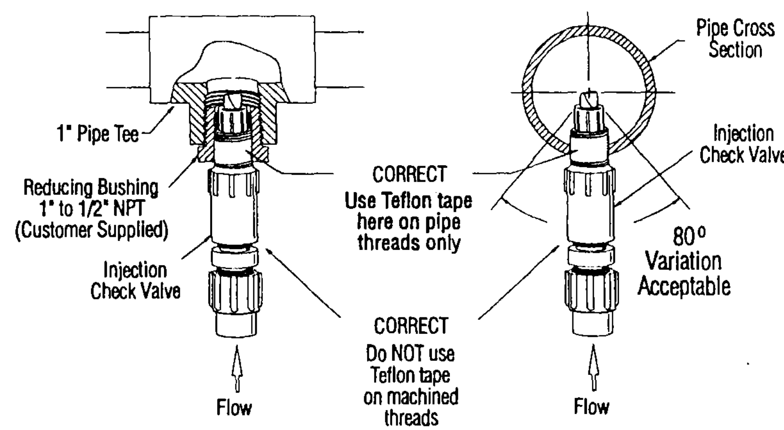
4.7 Injection Check Valve Installation

The Injection Check Valve prevents backflow from a treated line. Connect the Injection Check Valve to your "DISCHARGE" (outlet) line. Any size NPTF fitting or pipe tee with a reducing bushing to 1/2" NPTF will accept the injection check valve. Use Teflon tape or pipe dope to seal the pipe threads only.

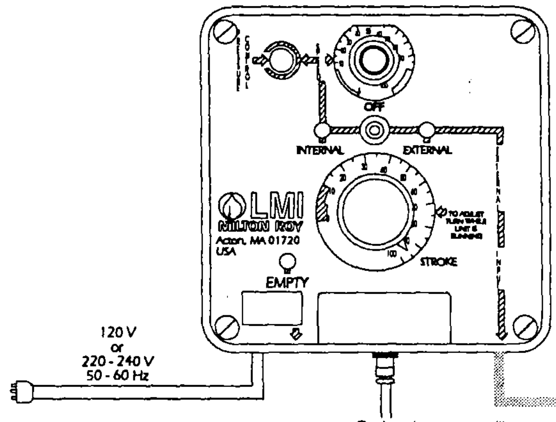
When installing the Injection Check Valve, be sure to position it so that the valve enters the bottom of your pipe in a vertical position. Variations left and right within 80° are acceptable. (See illustration below)

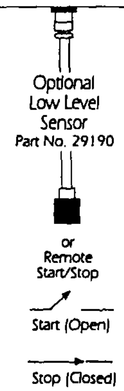
After cutting an appropriate length of tubing, connect tubing to the injection check valve then back to the discharge side of the pump head (top side), making sure it does not crimp or come into contact with hot or sharp surfaces.

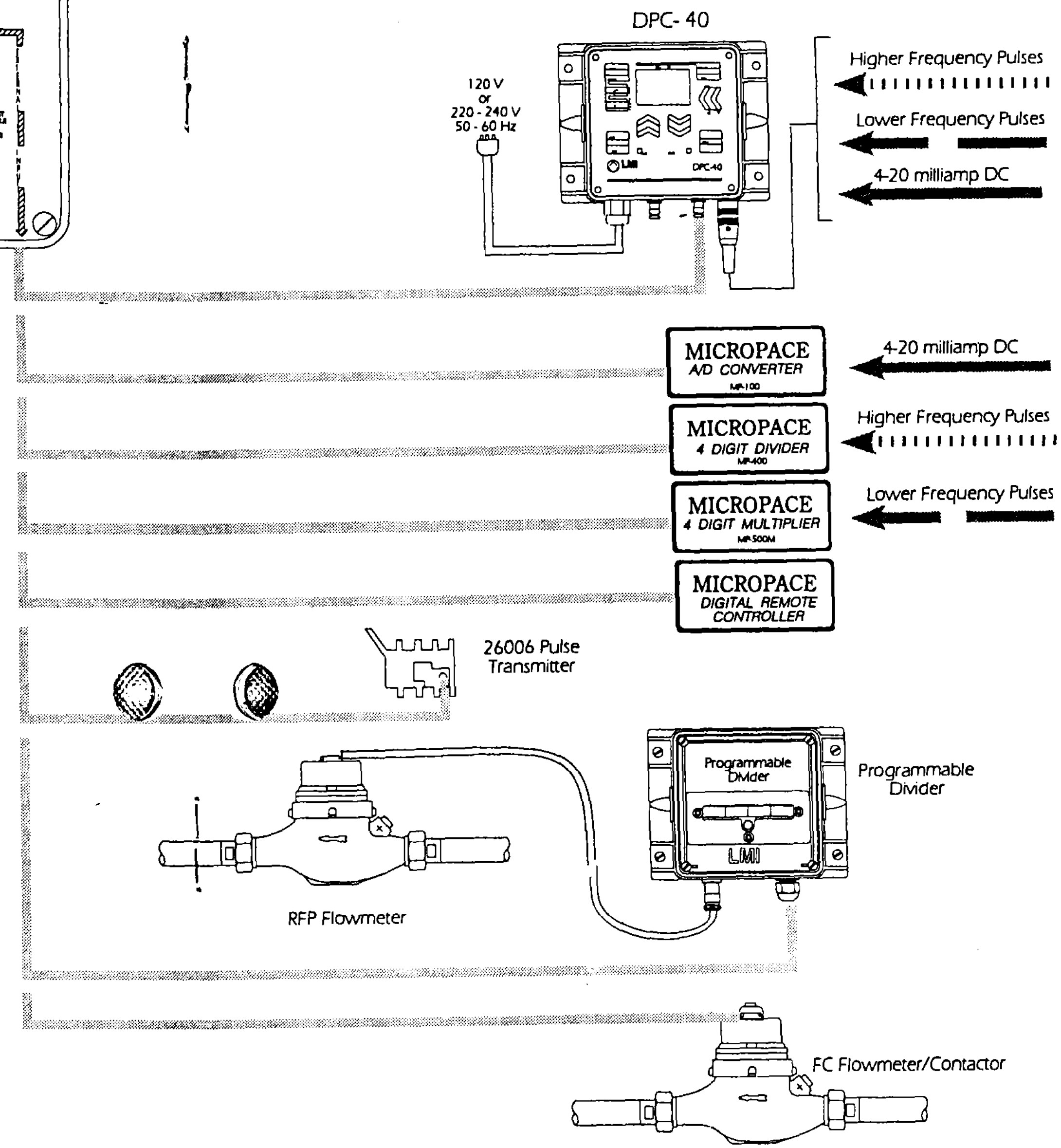
Typical Injection Check Valve Installations



5.0 METHODS OF EXTERNALLY TRIGGERING OR PACING A7, B7, C7 AND D7 PUMPS

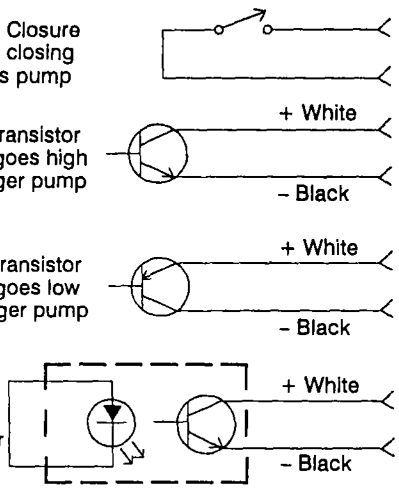






Methods of Triggering Metering (Dosing) Pumps

1. Switch Closure
   Switch closing triggers pump
2. NPN Transistor
   Base goes high to trigger pump
3. PNP Transistor
   Base goes low to trigger pump
4. Opto Isolator



Note:
Switch or transistors must be capable of switching 15V DC at 2 milliamperes. Minimum time in low impedance state (on) is 50 milliseconds. Minimum time in high impedance state (off) is 100 milliseconds.

6.0 START-UP and ADJUSTMENT

NOTE: The pump is normally self-priming if suction lift is 5 ft. (1.5m) or less and the steps below are followed.

NOTE: Pumps are shipped from the factory with water in the pump head to aid in priming.

6.1 Output Adjustment Controls

Note: Manual series pumps controls are not equipped with pressure control.

In most external controlled pumps the uppermost set of knobs on the control panel serve a dual purpose. The smallest of these knobs (inner knob of this concentric knob) is Pressure Control. The larger knob directly underneath is Speed Control. Graduation markings for the small Pressure Control Knob are etched in yellow on the Speed Knob itself. Graduations for the Speed Knob appear directly on the face of the control panel. The largest knob below is Stroke Control.

1. Pressure Control Adjustment: Pressure control provides the adjustment of the pump's pressure capability and power consumption, reducing heat, pipe shock and pulsation while increasing pump life. See Section 7.0 after priming for proper adjustment settings.

2. Speed Adjustment: Speed control provides adjustment of the percent of maximum strokes per minute. Turning this knob clockwise increases stroke frequency.

   Note A7 Series Only: When operating pump in external mode, the speed control knob should be turned fully counter clockwise . A click indicates pump is in external mode.

   Note A34 and A37 Series Only: Pump comes equipped with a range selector switch which

provides high or low speed adjustment. The high setting provides speed adjustments between 8-100 strokes per minute. The low setting provides accurate speed adjustments between 1-12.5 strokes per minute for applications requiring infrequent stroking.

3. Stroke Adjustment: Stroke control provides adjustment of percent of maximum Liquifram® (diaphragm) travel. Turning this knob clockwise increases percent output per stroke.

6.2 Start-Up/Priming for Pump Supplied with 4-FV

CAUTION: Read this entire section completely before proceeding.

When all precautionary steps have been taken, the pump is mounted, and the tubing is securely attached, you may now start priming the pump.

1. Plug in or switch the pump on.

2. While the pump is running, set the speed knob at 80% and the stroke knob at 100%.

   Note: If the pump is equipped with a pressure control knob, turn knob fully clockwise.

3. If your pump is equipped with a 4-FV, grip both the yellow and black knobs, 1/4 turn or pull and hold open.

4. The suction tubing should begin to fill with solution from the tank.

5. A small amount of solution will begin to discharge out the return line of the 4-FV. Once this happens, 1/4 turn or release the knobs and **SHUT THE PUMP OFF**. (If pump is not equipped with an on/off switch, disconnect the power cord.)

6. The pump is now primed.
7. Proceed to output adjustment, Section 6.4.

   NOTE: If the pump does not self-prime, remove the 4-FV on the discharge side of the pump head. Remove the ball and pour water or solution into the port until the head is filled. Replace valve, then follow start up/priming steps.

6.3 Start-Up/Priming without 4-FV

CAUTION: Read this entire section completely before proceeding.

When all precautionary steps have been taken, the pump is mounted, and the tubing is securely attached, you may now prime the pump.

1. Plug in or switch the pump on.
2. While the pump is running, set the speed knob at 80% and the stroke knob at 100%.

   Note: If the pump is equipped with a pressure control knob, turn knob fully clockwise.
3. The suction tubing should begin to fill with solution from the tank.
4. Once the solution begins to exit the pump head on the discharge side, **SHUT THE PUMP OFF**. (If pump is not equipped with an on/off switch, disconnect the power cord).
5. The pump is now primed.
6. Proceed to output adjustment, Section 6.4.

   NOTE: If the pump does not self-prime, remove the fitting on the discharge side of the pump head. Remove the ball and pour water or solution into the port until the head is filled. Replace valve, then follow start up/priming steps.

6.4 Output Adjustment

Once the pump has been primed, an appropriate output adjustment **MUST** be made, Pump output should be calculated and adjustments made accordingly.

TOTAL PUMP OUTPUT

Calculate the total output of the pump as follows:

PUMP OUTPUT = MAX PUMP OUTPUT x %SPEED x %STROKE

Example: A151-192S

Use MAX Output (From dataplate on bottom center of pump control panel) = 24 GPD (24 gallons per day).

If the pump is set at 60% speed and 70% stroke length, the approximate pump output is:

24.0 x 0.60 x 0.70 = 10.08 GPD (gallons per day) Divide by 24 (hours in one day) to calculate in gallons per hour.

Note: If pump is not equipped with speed adjustment, calculate by **Max Pump Output** x **% Stroke** only.

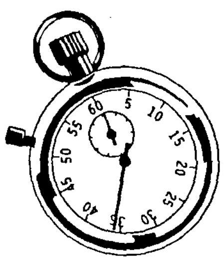
7.0 CALIBRATION

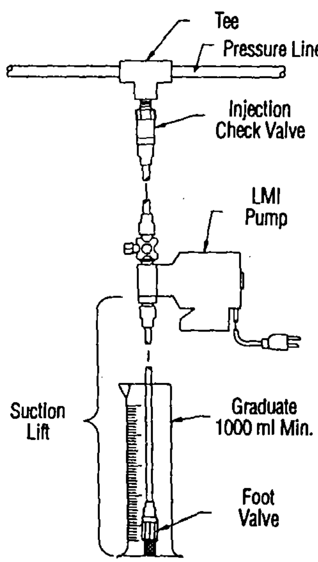
Once installation is complete and the approximate output has been determined, the pump should be calibrated to adjust speed and stroke for your actual desired output.

1. If equipped, make certain Pressure Control Knob is turned fully clockwise.
2. Be sure the pump is primed, and discharge tubing and Injection Check Valve are installed as they would be in normal service (i.e., including factors such as injection pressure, fluid viscosity, and suction lift).

3. Place the Foot Valve in a graduated container with a volume of 1000 ml or more.
4. Plug in and switch pump to Internal Mode. Pump until all the air is exhausted from the suction line and head.
5. Turn the pump off. Refill graduated container to a level starting point.

   NOTE: If pump is equipped with pressure control, see Section 7.1 before proceeding.
6. Using a stopwatch or timer, turn the pump on for a measured amount of time (50 pump strokes minimum). The longer the time period, the more confident you can be of the results. Be sure to count the number of strokes during the calibration period when making comparisons.
7. Turn the pump off. Note the time elapsed in relation to volume displaced in the graduate. Now, calculate the output in the time unit you choose (minutes, hours. days, etc.).
8. If the output is too low or too great, adjust speed and or stroke, estimating required correction and repeat steps 1-7.

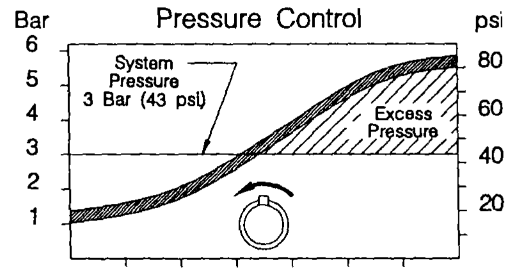




7.1 Pressure Control

Adjust Pressure Control: While unit is running, turn Pressure Control Knob slowly counter-clockwise until unit just begins to stall. From this stall point, now turn Pressure Control Knob clockwise from 1 to 1 1/2 graduation marks. This is the optimum pressure control setting for your application.

NOTE: Increase setting if back pressure is increased.



Adjust pressure control to reduce heat, shock, pulsations and prolong pump life.

7.2 Calibration Procedure - On-Site Volumetric Calibration in External Mode

1. Since pump output is governed by an external device such as Flowmeter-Pulser, Liquitron™ Current-to-Frequency Converter or 4-20 mA DC signal from an instrument with an LMI Analog-to Digital Converter, **only the output per stroke may be calibrated.**
2. With pump primed and discharge tubing connected to the injection point as it would be in normal service, place Foot Valve and Strainer Assembly in a graduated container with a volume of 500 ml or more.
3. Switch pump to **Internal** mode with Speed Knob set at 100 until air is exhausted from suction line and pump head.

4. **Adjust Pressure Control** - See Section 7.1.
5. Switch pump **OFF** and note solution level in graduated container. Refill graduate to a starting point.
6. Switch pump **ON** and **count the number of strokes** for exactly one minute. Then Switch pump **OFF.**
7. Note volume pumped during the calibration period of one minute. Divide into this the number of strokes to determine the volume of solution pumped per stroke.

   Example: 500 ml in 100 strokes=5.0ml per stroke.

   Multiply this by your expected stroke rate per minute, per hour or per day and compare with desired output requirements.
8. Adjust Stroke Length Knob (lower knob) to your best estimate of required correction and repeat calibration procedure.

8.0 SPARE PARTS REPLACEMENTS ROUTINE MAINTENANCE

8.1 Depressurizing the Discharge Line (For Pumps Equipped with a 4-FV only).

WARNING: ALWAYS wear protective clothing, face shield, safety glasses and gloves when performing any maintenance or replacement on your pump.

WARNING: Read steps 1 and 2 below before proceeding.

1. Be sure the Injection Check Valve is properly installed and is operating. If a shut off valve has

been installed downstream of the Injection Valve, it should be closed to off.

WARNING: Be sure your relief tubing is connected to your 4-FV and runs back to your solution drum or tank.

2. 1/4 turn or pull on both the yellow and black knobs on the 4-FV. The discharge line is now depressurized. Keep valve open until solution drains back down the discharge tubing into solution drum or tank. Then release or 1/4 turn knobs to normal position.

8.2 Liquifram® (Diaphragm) Replacement

WARNING: ALWAYS wear protective clothing, face shield, safety glasses and gloves when working near or performing any maintenance or replacement on your pump. See MSDS Sheet from solution supplier for additional precautions.

LMI metering pumps are designed for trouble-free operation, yet routine maintenance of elastomeric parts is essential for optimum performance. This involves replacing the Liquifram® seal rings, valve balls, and the Injection Check Valve spring. LMI recommends replacing these parts at least once a year, however, frequency will depend on your particular application.

When replacing the Liquifram®, the valve balls, seal rings and the injection check valve spring should also be replaced. See next section (8.3). A Spare Parts Kit (SP-#) containing these parts may be obtained from your local distributor. (See the Liquid Handling Assembly Sheet for Spare Parts Kit Part Number).

1. Carefully depressurize, drain, and disconnect the discharge line (See Section 8.1 in this manual). Place the Foot Valve into a container of water or other neutralizing solution. Turn the pump on to flush the head assembly. Once the pump head has been flushed, lift the Foot Valve out of the solution and continue to pump air into the pump head until the pump head is purged of water or neutralizing solution.

   Note: If the liquid cannot be pumped due to Liquifram® rupture, using protective gloves, carefully disconnect the suction and discharge tubing. Remove the four screws to the head and immerse the head in water or other neutralizing solution.

2. Start the pump. While running, set the stroke knob to zero and turn the pump off.

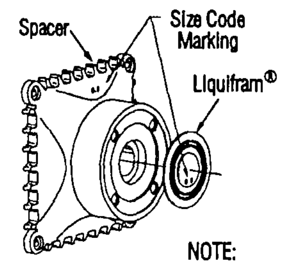
   NOTE: See Section 9.0 for proper zeroing.

3. With the unit off, unscrew the Liquifram® by carefully grasping the outer edge of the Liquifram® and turning it counter clockwise. Discard old Liquifram® . Remove the Liquifram® disk if so equipped (located behind the Liquifram®) and check that the size code matches the size code on the replacement Liquifram® (see illustration).

4. Reinstall the disk so the alignment pin on the disk (if present) seats in the recessed hole in the EPU.

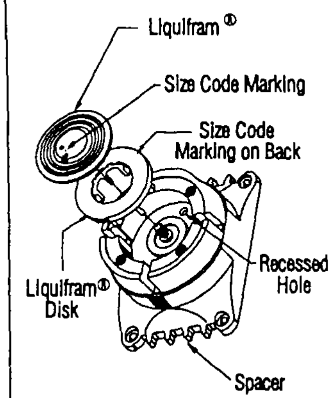
WARNING: Take care not to scratch the Teflon face of the new Liquifram® .

For Series B, C, & E



NOTE:
Size code markings for pumps supplied with 6.0 Liquiframs® (diaphragms) should be referenced to the 6.0 Black Adapter not the 3.0 Spacer

For Series A, J, & P

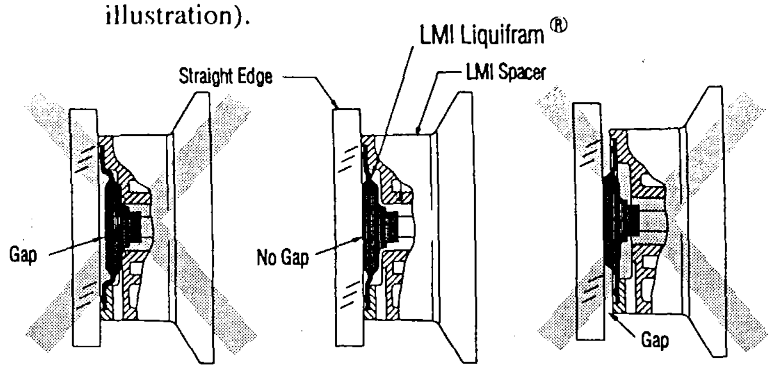


5. Start the pump and turn the stroke knob to the setting indicated below on Stroke Setting Chart which matches the pump model number located on the pump dataplate. With the pump stroking (running), screw on the new Liquifram® clockwise until the center begins to buckle inwards. Stop the pump.

Liquifram® Stroke Setting Chart

Pump Series	Stroke Knob Setting
All A, B, J, P, Z Series C10, C11, C12, C70, C71, C72, E70, E71, E72	90%
All L Series,	85%
C78	50%
C13, C14, C73, C74, C77 E73, E74	70%
All U and M Series	100% but Liquifram® must be bottomed completely. (Turned all the way) **Do Not Use Straight Edge.**

6. Grasp the outer edge of the Liquifram® and adjust by screwing it in or out so that the center of the Liquifram® is flush with the outside of the spacer edge (see illustration).



(Liquifram ® is flush with spacer and straight edge)

7. Once the Liquifram® is properly positioned, remount the pump head to the spacer using the four (4) screws. Tighten in a crisscross pattern. After one week of operation, recheck the screws and tighten if necessary.

8.3 Seal Ring, Ball and Injection Check Valve Spring Replacement

WARNING: ALWAYS wear protective clothing, face shield, safety glasses and gloves when working on or performing any maintenance or replacement on your pump. See MSDS Sheet from solution supplier for additional precautions.

1. Refer to the Liquid Handling Assembly Sheet included with your pump for the proper Spare Parts Kit number.

2. Carefully depressurize and disconnect the discharge line (See Section 8.1 in this manual). Place the Foot Valve into a container of water or other neutralizing solution. Turn the pump on to flush the head assembly.

Once the pump has been flushed, lift the Foot Valve out and continue to pump to let air into the pump head until pump is purged of water or neutralizing solution.

If the liquid cannot be pumped due to Liquifram® rupture, with protective gloves, carefully disconnect the tubing and four screws to remove the head. Immerse the head in water or other neutralizing solution.

IMPORTANT: Before disassembling valves, note the orientation of seal ring and ball. (See illustration)

3. Carefully disconnect one tubing connection and fitting at a time and remove the worn seal ring and ball.

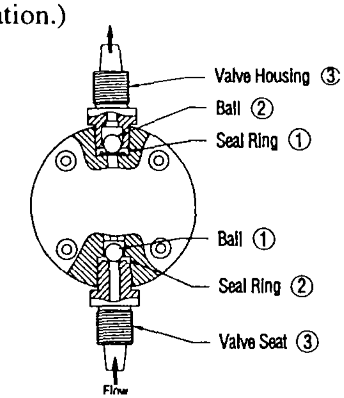
   Carefully loosen sealing by prying side to side using a small screw driver through the center hole of the seal ring.

4. Install new seal ring and ball in each location. **IMPORTANT**: Note correct orientation.

5. Install the new spring in the Injection Check Valve.

WARNING: Depressurize and drain pipeline (or isolate I.C.V. point using valves) so that I.C.V. can safely be disassembled.

(Refer to Liquid Handling End Sheet for proper assembly orientation.)



Order of Installation

Note: Order of assembly changes depending on valve location

9.0 CHECKING PUMP FOR PROPER ZEROING (STROKE KNOB)

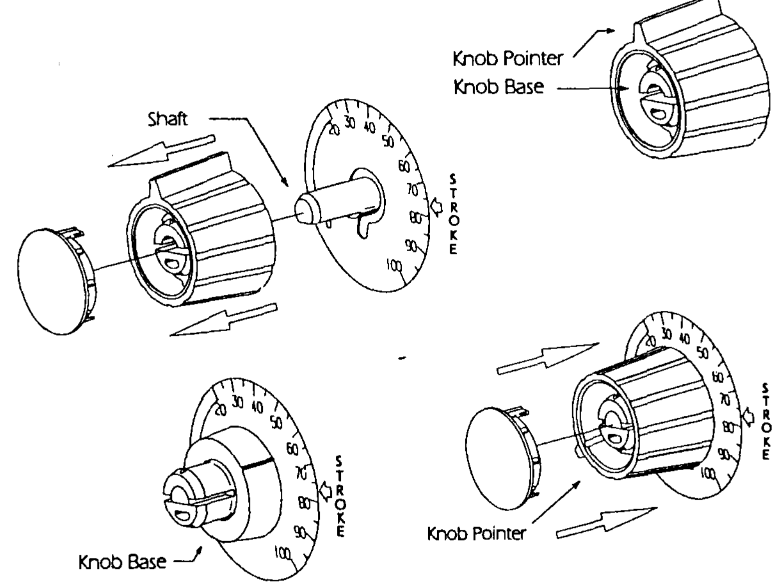
1. With pump running, turn stroke knob counterclockwise toward zero or end of black or red band.
2. LISTEN to the clicking as the pump is running. The pump should operate quietly at the zero position (no clicking).
3. If the pump continues to click at zero or stops clicking before zero is reached, the pump zero must be reset. (See Section 9.1 or 9.2)

9.1 Type I - Push on Knob

Rezeroing and Stroke Knob Disassembly and Assembly

1. Remove stroke knob from the pump by grasping the knob firmly and pulling it toward you.
2. Pry off the yellow cap.
3. Place the knob on a flat surface.
4. Using needle nose pliers, squeeze the inner section together while lifting the outer section up.
5. Push the inner section back onto the "D" shaped stroke shaft.
6. With the pump running, zero the pump by turning the inner section of the knob counter clockwise until the pump stops clicking.
7. Position the outer section of the knob so that the pointer aligns with zero on the nameplate or end of the black or red band.
8. Push down on the outer section (a snap sound indicates parts are locked together).
9. Replace the yellow cap over the outer section of the knob, aligning the tabs on the cap with the slots inside the knob.

Stroke Knob Assembly (Type I)



9.2 Type II Collet Knob

Rezeroing and Stroke Knob Disassembly and Assembly

1. Remove Yellow Cap.
2. Hold knob with soft jaw pliers.
3. Disconnect knob by loosening 5/16" (8 mm) collet nut. There is no need to remove nut.
4. Remove knob by pulling towards you.
5. With pump running, zero the pump using a screw driver to turn the stroke shaft counter-clockwise until the pump just stops clicking.
6. Pump is now zeroed.
7. Position knob at zero, or the end of the low range band, and tighten 5/16" (8 mm) collet nut).
8. Replace yellow cap.

10.0 TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE
Pump Will Not Prime	1. Pump not turned on or plugged in.
	2. Output dials not set properly.
	3. Foot Valve not in vertical position on bottom of tank.
	4. Pump suction lift too high.
	5. Suction tubing is curved or coiled in tank
	6. Fittings are over tightened.
	7. Air trap in suction valve tubing.
	8. Too much pressure at discharge. (Pumps without 4-FV)
Pump Loses Prime	1. Solution container ran dry
	2. Foot Valve is not in a vertical position on the bottom of the tank.
	3. Pump suction lift is too high.
	4. Suction tubing is curved or coiled in tank.
	5. Fittings are overtightened.
	6. Air trap in suction valve tubing.
	7. Air leak on suction side.

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To keep your LMI pump in good health...
If you are an LMI pump owner, find the last digits of your LMI pump model number (the digits following the dash) and circle the spare parts kit number which is correct for your pump. We suggest you check with your supplier to order a kit or make sure that one is readily available locally. These kits include the liquid handling parts which normally require periodic replacement.

SPART PARTS KIT NO.	FINAL DIGITS OF PUMP MODEL NO.*
SP-U1	81S, 81T, 82A, 82T, 85S, 85T, 91T, 91TU, 92S, 92T, 92TU, 94, 94S, 95, 95P, 95S, 95SU, 95T, 196, 196S, 196SU, 196U
SP-U2	65, 65S, 71A, 71S, 71T, 72S, 72T, 74, 74S, 75P, 75S, 75T
SP-U3	81F, 81FS, 91F, 91FS
SP-U4	71F, 71FS
SP-U5	24, 25, 25P, 25T
SP-U6	30, 30S, 34, 35P, 35T, 36, 36S
SP-U7	190, 190S, 190SU, 190U, 191, 191S, 191SU, 191U, 192, 192S, 192SU, 192U, 193, 193S, 193SU, 193U, 198, 198S, 198SU, 198U
SP-U8	151, 151P, 151S, 151SU, 151U, 152, 152S, 152SU, 152U
SP-U9	155, 155P, 155S, 155SU, 155U
SP-U10	62, 62S, 168, 168S, 171, 171S, 172, 172S
SP-U14	150, 150S, 150SU, 150U
SP-U17	112, 112S, 118, 118S

*If the final digits of the model number of your pump are not listed above, your spare parts kit number is "SP-" followed by the final digits of your pump's model number.

SOLUTION
1. Turn on pump/plug in pump.
2. Always prime pump with speed at 80% and stroke at 100%.
3. Foot Valve must be vertical (See Foot Valve Installation, Section 4.6).
4. Maximum suction lift is 5 ft. (1.5 m) Pumps with High Viscosity Liquid Handling Assemblies require flooded suction.
5. Suction tubing must be vertical. Use LMI tubing straightener supplied with pump. (See Section 4.6)
6. Do not overtighten fittings. This causes seal rings to distort and not seat properly which causes pump to leak back or lose prime.
7. Suction tubing should be as vertical as possible. AVOID FALSE FLOODED SUCTION! (See Section 4.2A)
8. Shut off valves in pressurized line. Disconnect tubing at injection check valve (See priming Section 6.0). When pump is primed, reconnect discharge tubing.
1. Refill container with solution and reprime (See Section 6.0)
2. Foot Valve must be vertical (See Foot Valve Installation, Section 4.6).
3. Maximum suction lift is 5 ft. (1.5 m). Pumps with High Viscosity Liquid Handling Assemblies require flooded suction.
4. Suction tubing must be vertical. Use LMI tubing straightener supplied with pump. (See Section 4.6)
5. Do not overtighten fittings. This causes seal rings to distort and not seat properly which caused pump to leak back or lose prime.
6. Suction tubing should be as vertical as possible. AVOID FALSE FLOODED SUCTION! (See Section 4.2A)
7. Check for pinholes, cracks. Replace if necessary.

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LIMITED WARRANTY

1. Seller warrants that the equipment delivered by it to the Buyer is in accordance with the Seller's published specifications and is of the kind and of the description contained in seller's invoice.

THIS WARRANTY IS IN LIEU OF AND TO THE EXCEPTION OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT BY WAY OF LIMITATION, WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. DISTRIBUTOR IS NOT AUTHORIZED TO BIND THE COMPANY FOR ANY OTHER WARRANTY. THE FOREGOING STATES THE COMPANY'S ENTIRE AND EXCLUSIVE LIABILITY, AND DISTRIBUTOR AGREES TO HOLD THE COMPANY HARMLESS FROM AN IMPROPER APPLICATION OF PRODUCTS.

2. Seller's liability for breach of the foregoing warranty is expressly limited to the repair or, at Seller's option, replacement of such equipment FOB factory, or Acton, MA. Such obligation to repair or replace such equipment shall terminate 12 months after the delivery to such equipment to the Buyer. In no event shall the Seller be liable for any consequential damages resulting from any breach of warranty.

The Company warrants the Products in accordance with the statement of warranty policy ...herein except that pump Product series designated as "A", "B", "C", "E", "G" "P", "H" ...oller series designated as AC, DC, DP, DR, DT, and FS shall be warranted for a period of two (2) years from the date of delivery from Company; and except replacement elastomeric expendable parts which are not covered by any warranty either express or implied.

The Buyer claims that the warranty contained herein has been breached, it shall immediately notify the Seller of such claimed breach in writing at Seller's address contained herein. The Buyer shall render necessary assistance to Seller, and it shall furnish adequate means for operating and testing such equipment.

The SOLE PURPOSE of the foregoing stipulated exclusive remedy shall be to provide to the Buyer free repair or at Seller's option replacement of non-conforming equipment in the manner provided herein. This EXCLUSIVE REMEDY shall not be deemed to have failed of its essential purpose so long as the Seller is willing and able to repair or at its option replace non-conforming equipment in the prescribed manner.

3. Seller shall not be liable for any loss or damage for delays in delivery or compliance with any warranty provision contained herein due to acts of God, acts of civil or military authorities, fires, floods, wars, riots, labor strikes or actions, accidents or delays in transportation or any other cause beyond the Seller's control.

4. All Shipments by Company to Distributor shall be made F.O.B. Factory, Acton, Massachusetts 01720, U.S.A. unless special arrangements are agreed to by both Company and Distributor.

5. The within terms and conditions constitute the entire agreement of the Buyer and Seller. Such terms and conditions may not be modified, altered or amended except by a writing signed by both parties. Such terms and conditions shall be binding upon the parties hereto, their successors and assigns. In the event that any term or condition shall be held to be invalid or unenforceable, all other terms shall remain in full force and effect. Such terms and conditions shall be governed and construed in accordance with the laws of the Commonwealth of Massachusetts.

TROUBLESHOOTING (continued)

PROBLEM	POSSIBLE CAUSE	SOLUTION
Leakage at tubing	1. Worn tubing ends.	1. Cut tubing about 1inch (25 mm) off tubing and then replace as before.
	2. Loose or cracked fitting.	2. Replace fitting if cracked. Carefully hand tighten fittings. Do not use pipe wrench. Once fitting comes into contact with seal ring, tighten an additional 1/8 or 1/4 turn.
	3. Worn seal rings.	3. Replace balls and seal rings. (See Section 8.3) Spare Parts (SP-#)
	4. Solution attacking Liquid Handling Assembly material.	4. Consult LMI or your local distributor for alternate materials.
Low Output or Failure to Pump Against Pressure	1. Pump's maximum pressure rating is exceeded by injection pressure.	1. Injection pressure cannot exceed pump's maximum pressure. See pump data plate.
	2. Worn Seal Rings.	2. Worn seal rings may need replacement. (See Section 8.3) Spare Parts (SP-#)
	3. Ruptured Liquifram®.	3. Replace Liquifram®. (See Section 8.2)
	4. Incorrect stroke length.	4. Check zero on pump/Re-zero pump. (See Section 9.0)
	5. Tubing run on discharge may be too long.	5. Longer tubing runs may create frictional losses sufficient to reduce pump's pressure rating. Consult factory for more information.
	6. Clogged footvalve strainer.	6. Remove footvalve strainer when pumping slurries or when solution particles cause strainer to clog.
Failure to Run	1. Pump not turned on or plugged in.	1. Turn on or plug in pump.
	2. EPU failure.	2. Disassemble pump and measure the resistance of the EPU across the EPU wires. Resistance reading should be in accordance to the table (See Section 11.0). Also check EPU leads to ground. Consult supplier or factory.
	3. Pulser failure.	3. The pulser should be replaced if EPU checks out OK. Consult supplier or factory.
Excessive Pump Output	1. Syphoning. (Pumping downhill without a 4-FV).	1. Move injection point to a pressurized location or install an LMI 4-FV. (See Section 4.4)
	2. Little or no pressure at injection point.	2. If pressure at injection point is less than 25 psi, an LMI 4-FV should be installed. (See Section 4.4)
	3. Excessive strokes per minute.	3. Replace pulser or resistor. Consult factory.

11.0 EPU RESISTANCE CHART

Pump Series	Voltage	Coil Resistance (Ohms) * @ 20°C (68° F)
A14, A15, A16, A34, A74, A75, A76 A94, A95, A96 J02, J03, J04 , J05, J06 J13, J15, J16 PW4, PW5, PW6 P04, P05, P06 P14, P15, P16 U01,U02,U03	115 VAC 230 VAC	76 - 87 307 - 353
A17,A37,A77,A97,A18,A78 P02,P03 P12,P13 (NOTE 1)	115 VAC 230 VAC	152 - 176 583 - 671
A17, A37, A77, A97, A18, A78 P02, P03 P12,P13,P77 (NOTE 2)	115 VAC 230 VAC	76- 87 291- 335
J54D, J55D, J56D	12 VDC	1.1 - 1.3
D10, D11, D12, D13, D14 D70, D71, D72, D73, D74	115 VAC 230 VAC	25.7- 29.6 97 - 112
E70, E71, E72, E73, E74	115 VAC 230 VAC	22.8 - 26.2 91 - 105
B11, B12, B13, B14 B71, B72, B73, B74	115 VAC 230 VAC	43 - 49 167 - 193
C10, C11, C12, C13, C14 C70, C71, C72, C73, C74	115 VAC 230 VAC	22.8 - 26.2 91 - 105
C77, C78	115 VAC 230 VAC	14.4 - 16.6 57.7 - 66.3

NOTES
1. Pumps with serial numbers **lower** than 960113429 .
2. Pumps with serial numbers **higher** than 960113429 .

* EPU checked within 10 hours of operation can increase coil resistance reading as much as 20%

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LE-190S LE-190SU
LIQUID HANDLING ASSEMBLY
CAUTION

When pumping solutions make certain that all tubing is securely attached to the fittings. It is recommended that tubing or pipe lines be shielded to prevent possible injury in case of rupture or accidental damage. Always wear protective clothing and face shield when working on or near your metering pump.

Note: See parts list for materials of construction

A. INSTALLING INJECTION CHECK VALVE

1. The purpose of the injection check valve is to prevent backflow from the treated line.
2. A 1/2" NPT female fitting with sufficient depth will accept the injection check valve.
3. To insure correct seating of the ball inside the injection check valve, the injection check valve should be installed upwards (vertically) into bottom of the pipe.

B. CONNECTING DISCHARGE TUBING

NOTE:
Cut tubing to length needed for discharge line.

1. Route tubing from the injection check valve to the metering pump, making sure it does not touch hot or sharp surfaces, or is bent so sharply that it kinks.
2. Slide the small end of the coupling nut onto tubing.
3. Slide the long, straight end of the ferrule onto tubing such that tubing exits at the cone shaped end of the ferrule.
4. Insert tubing into the valve housing so that tubing butts up against valve housing and will not go any further.
5. Slide ferrule down so that the cone shaped end fits snugly into valve housing.
6. Slide the coupling nut to the threads and engage. While pushing the tubing into valve housing, tighten the coupling nut by hand until tubing is held securely in place.

EXCESSIVE FORCE WILL CRACK OR DISTORT FITTINGS. DO NOT USE PIPE WRENCH.

C. CONNECTING SUCTION TUBING

1. Cut suction tubing to a length so that the foot valve hangs just above the bottom of the solution container. Maximum recommended vertical suction lift is 5 ft. (1.5m).
2. Follow same procedure in connecting suction tubing to suction valve and foot valve (see B. Connecting Discharge Tubing).

D. PRIMING

1. Connect pressure relief tubing to pressure relief port on the four function valve.
2. Route tubing to solution reservoir and anchor with a plastic tie. Do not submerge tubing in solution.
3. Start pump. Set at 80% speed and 100% stroke.
4. Pull on Pressure Relief knob (red or black knob), holding knob out until solution is visible through translucent return tubing.
5. The pump is now primed.

NOTE:
(a) Pump is normally self-priming if suction lift is not more than 5 ft. (1.5m), valves in the pump are wet with water (pump is shipped from factory with water in pump head) and the above steps (D. Priming) are followed.
(b) If the pump does not self prime, remove discharge valve housing and ball and pour water or solution slowly into discharge port until head is filled. Follow step D. Priming thereafter.

E. DEPRESSURIZING DISCHARGE LINE

1. It is possible to depressurize the discharge line and pump head without removal of tubing or loosening of fittings.

Be sure injection check valve is properly installed and is operating. If a gate valve or globe has been installed downstream of injection check valve, it should be closed. Be certain relief tubing from the four function valve is connected and run to solution reservoir.

2. Pull on both anti-syphon and relief knobs.
3. The discharge line is now depressurized.
4. If injection check valve is of higher elevation than pump head, disconnecting tubing at injection check valve end will allow air to enter and cause solution to drain back to tank.

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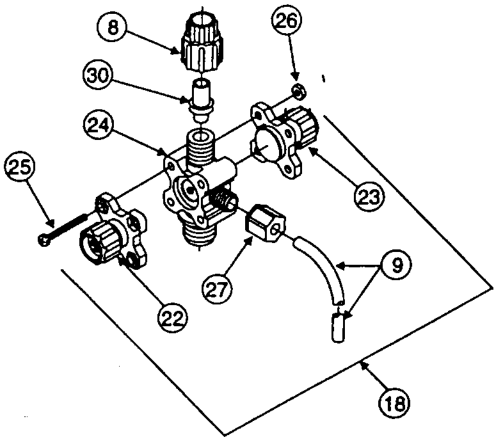
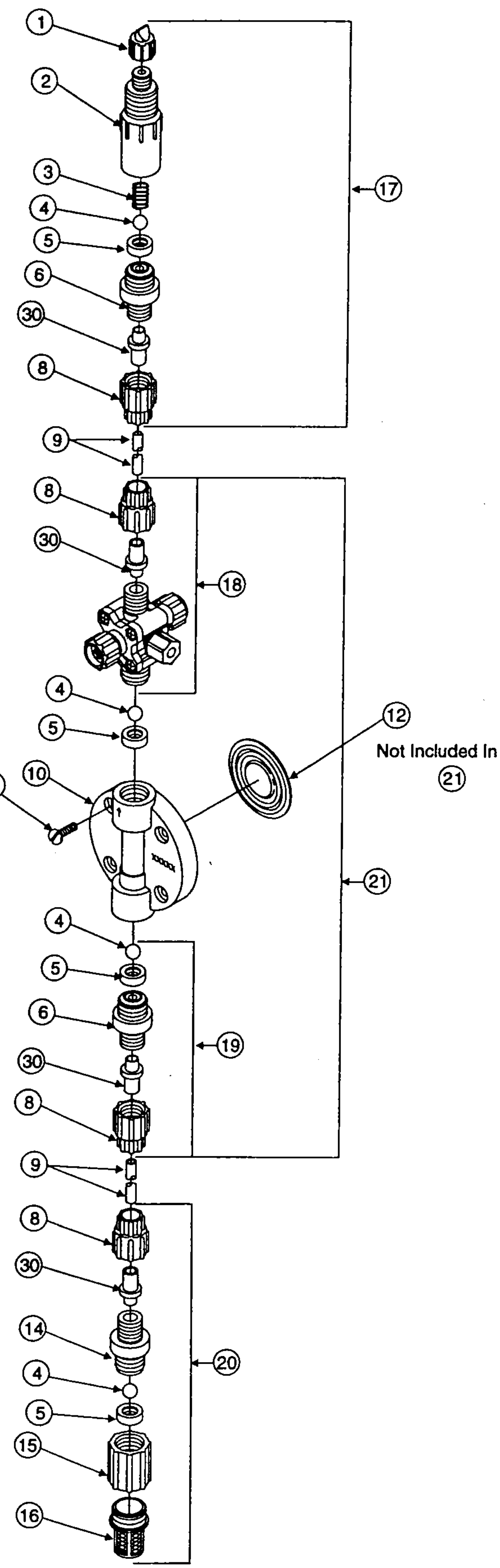
Replaces same of Rev. C 7/94
1555.C 8/96

Note: Threaded connections into pump head are 3/4" - 16 straight threads. **DO NOT USE TEFLON TAPE**. These joints are sealed by seal ring valve seats (item 5 on exploded view).





KEY NO.	PART NO.	DESCRIPTION	Quantity LE-190S	Quantity LE-190SU
1	27352	Flapper Valve, Flexoprene	1	1
2	10394	Injector Fitting, Polypropylene	1	1
3	10339*	Spring, PVDF	1	1
4	10338*	Ball, Ceramic .375	4	4
5	29443*	Seal Ring, Polyprel	4	4
6	28664	Valve Seat, Polypropylene	2	2
8	10299	Coupling Nut	4	4
9	25636-16	Tubing, .250" O.D. Polyethylene	1	
	25636-10	Tubing, .250" O.D. Polyethylene	1	
	28636-16	Tubing, .250" O.D. UV Polyethylene		1
	28636-10	Tubing, .250" O.D. UV Polyethylene		1
10	29610	Head, 0.9 SI, GFR Polypropylene	1	1
11	10340	Screw, 10-24 x 3/4" SS	4	4
12	30917*	Liquifram, 0.9 SI Fluorofilm®	1	1
14	28665	Valve Housing, Polypropylene	1	1
15	10978	Foot Valve Seat	1	1
16	10123	Strainer, Polypropylene	1	1
17	28001	Inj. Check/Valve Asm	1	1
18	28010	Anti-Syphon/Pressure Relief Valve Asm	1	
	31693	Anti-Syphon/Pressure Relief Valve Asm		1
19	28004	Suction Valve Assembly	1	1
20	28002	Foot Valve Assembly	1	1
21	28009	Head Assembly, LE-190S	1	
	31685	Head Assembly, LE-190SU		1
22	25837	Relief Cap Assembly	1	1
23	25838	Anti-Syphon Cap Assembly	1	1
24	28703	Valve Body, GFR Polypropylene	1	1
25	25627	Screw, 6-32 x 1 1/4" SS	4	4
26	25628	Nut, Hex 6-32 SS	4	4
27	25631	Coupling Nut	1	1
30	28663	Ferrule	4	4
	32293	Suction Tubing Straightener (not shown)	1	1

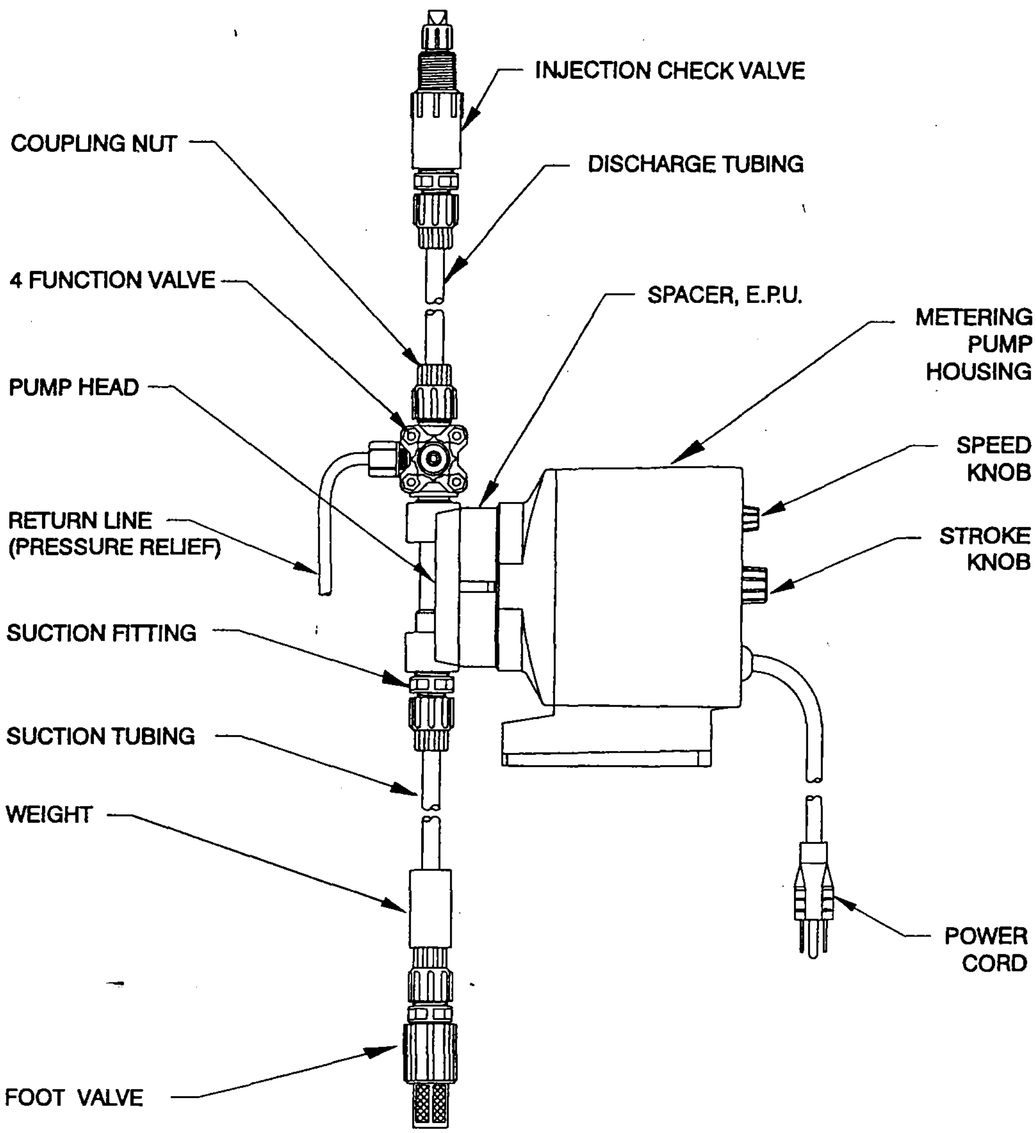
*Parts included in Spare Parts Kit Sp-U9

Printed in USA
Specifications subject to change without notice.

Instruction **Supplement**

Series P1

Electronic Metering Pump



Metering Pump Component Diagram

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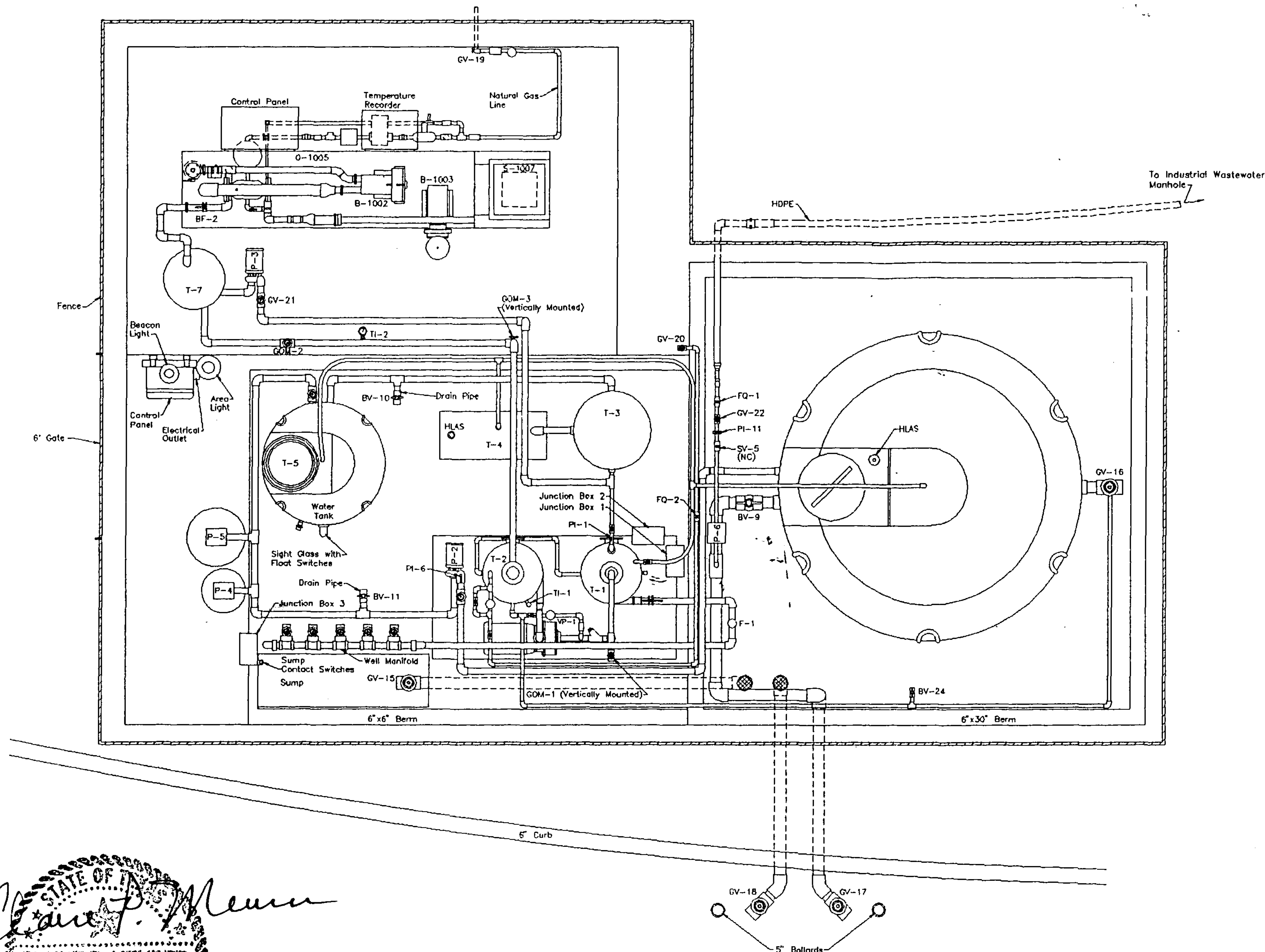
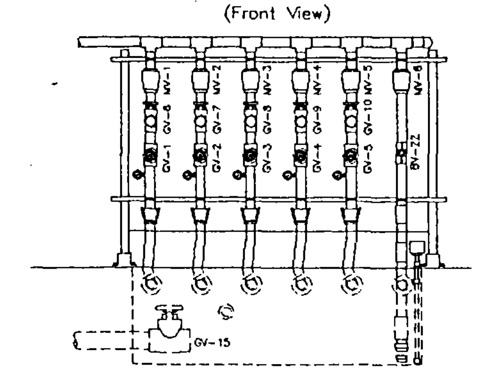
1842.A 4/97

ISO9001



Manifold Detail (Front View)

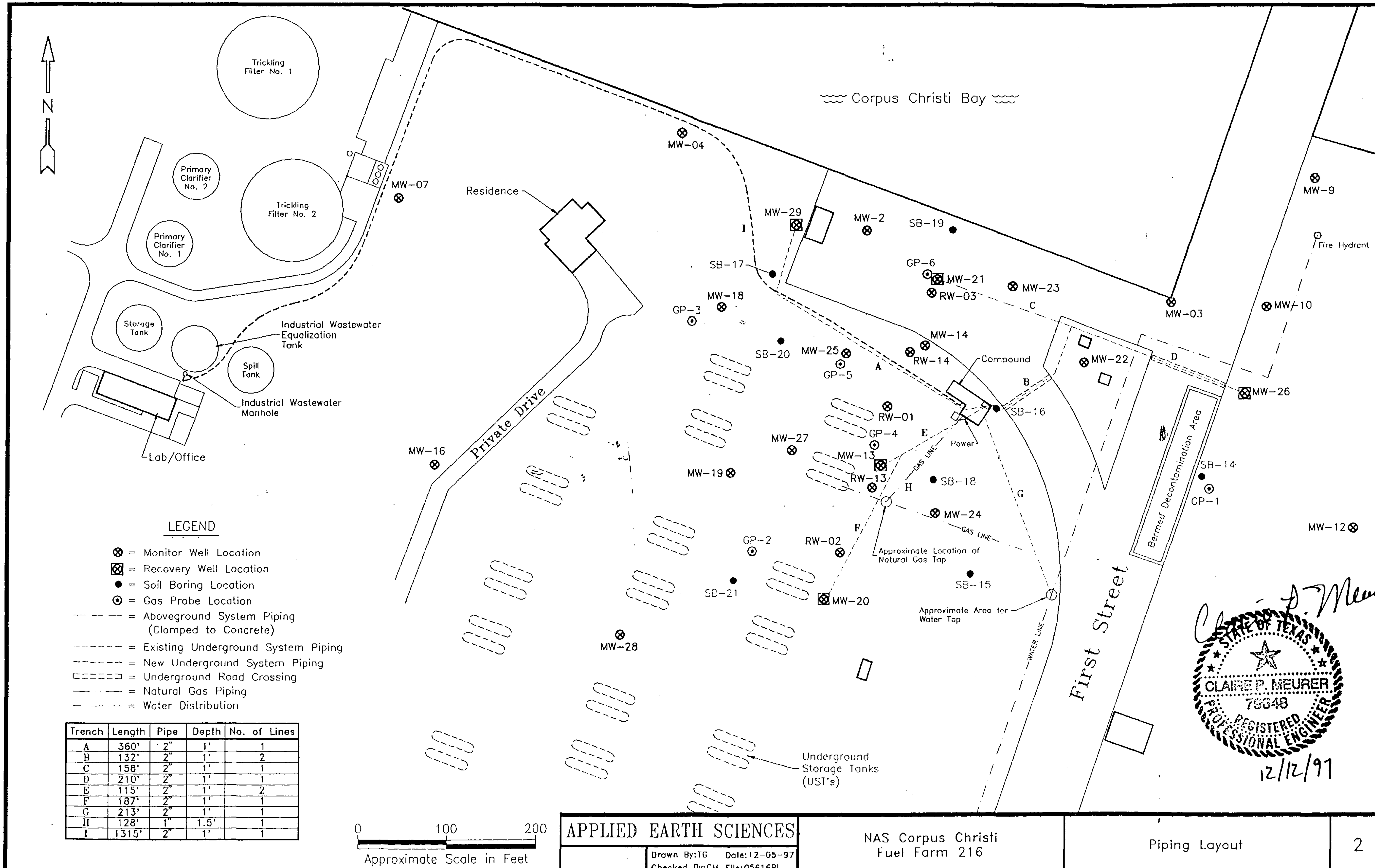


STATE OF TEXAS
CLAIRE P. MEURER
79648
REGISTERED PROFESSIONAL ENGINEER

12/12/97

Scale - 1" = 48"

APPLIED EARTH SCIENCES		Revised 10-18-96 Revised 02-12-97 Revised 06-05-97 Revised 09-02-97 Revised 12-03-97	As Built Treatment Compound Layout	1
04000-1	T. Gibson 10-06-96 Ref.File 040001			



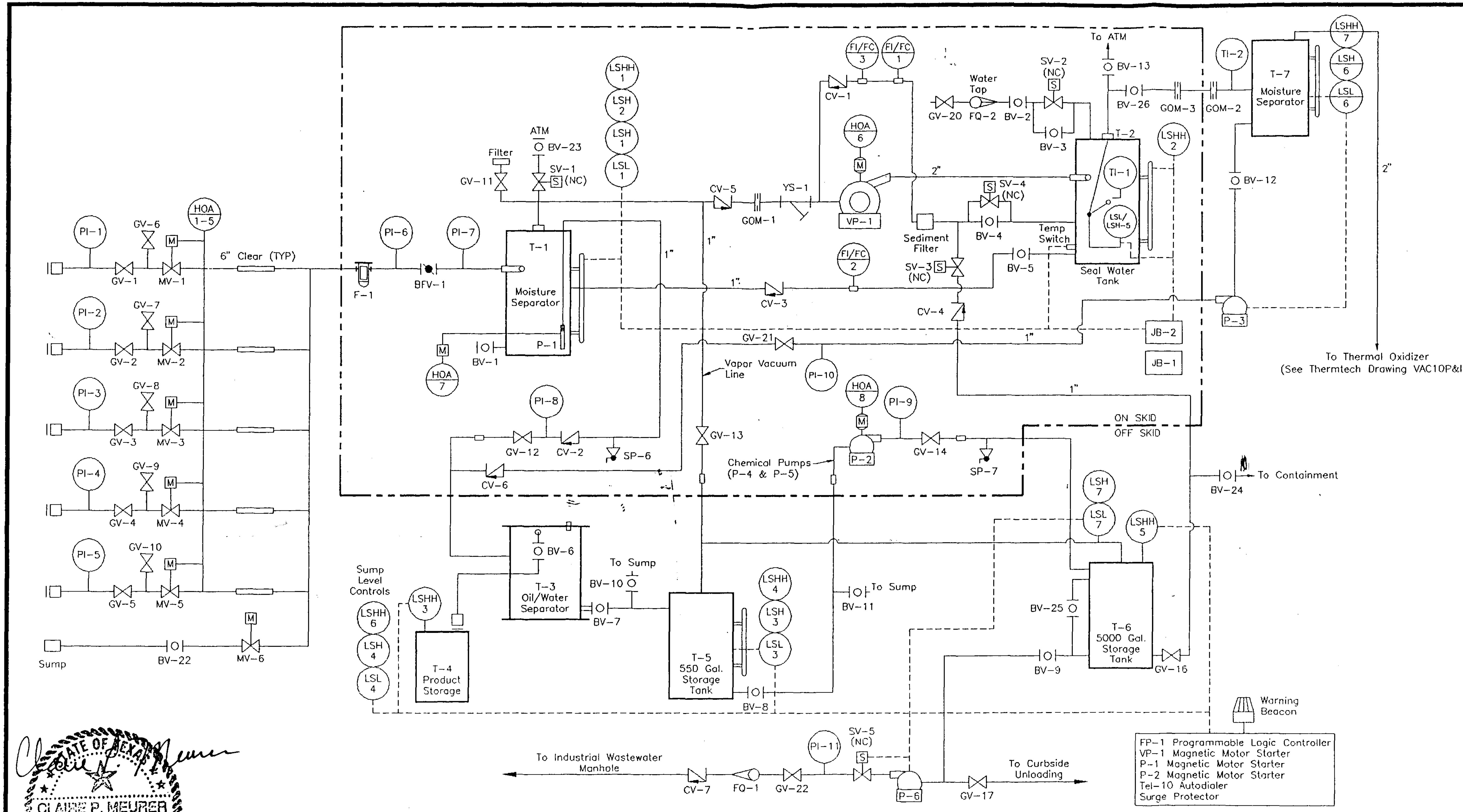
LEGEND

- ⊗ = Monitor Well Location
- ⊠ = Recovery Well Location
- ● = Soil Boring Location
- ⊙ = Gas Probe Location
- = Aboveground System Piping (Clamped to Concrete)
- = Existing Underground System Piping
- = New Underground System Piping
- = Underground Road Crossing
- = Natural Gas Piping
- = Water Distribution

Trench	Length	Pipe	Depth	No. of Lines
A	360'	2"	1'	1
B	132'	2"	1'	2
C	158'	2"	1'	1
D	210'	2"	1'	1
E	115'	2"	1'	2
F	187'	2"	1'	1
G	213'	2"	1'	1
H	128'	1"	1.5'	1
I	1315'	2"	1'	1

STATE OF TEXAS
CLAIRE P. MEURER
79348
REGISTERED PROFESSIONAL ENGINEER
12/12/97

APPLIED EARTH SCIENCES	NAS Corpus Christi Fuel Farm 216	Piping Layout	2
Drawn By: TG Date: 12-05-97 Checked By: CM File: 05616PL			



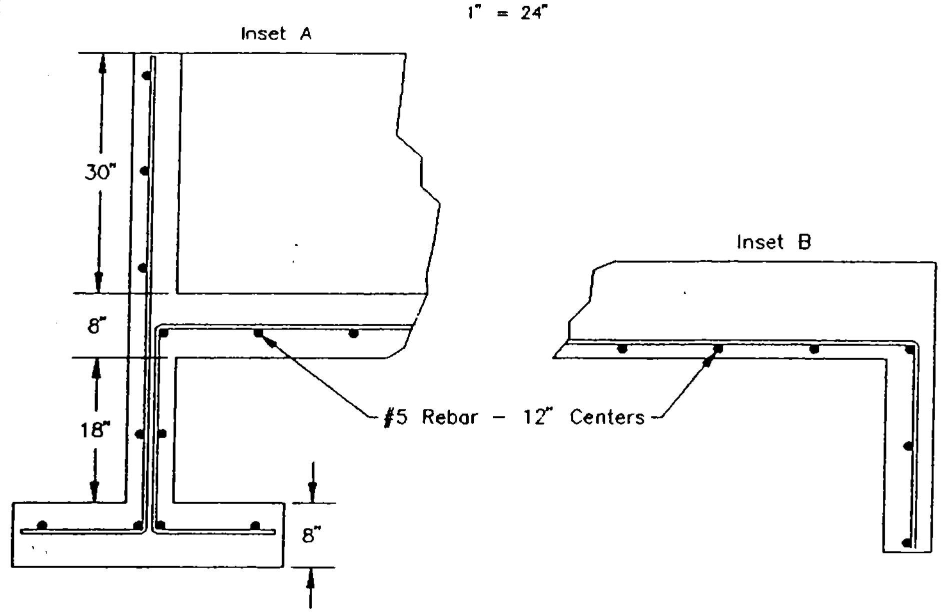
NOTES:

A) System Air Flow Rate is 75 CFM @ 25' Hg
B) System Water Flow Rate is 15 GPM
C) NEMA 4 Controls Off Skid
D) 4'x8' Skid
E) All Process Piping is 2" Sch. 40 PVC Unless Otherwise Noted
F) CV-3 is a Spring Loaded Check Valve (Prevents Water Level Equalization if System Fails)
G) 240 VAC, 1 Phase Power

APPLIED EARTH SCIENCES T. Gibson 12-05-97 Ref.File 05616PFD	Process Flow and Instrumentation Diagram	3

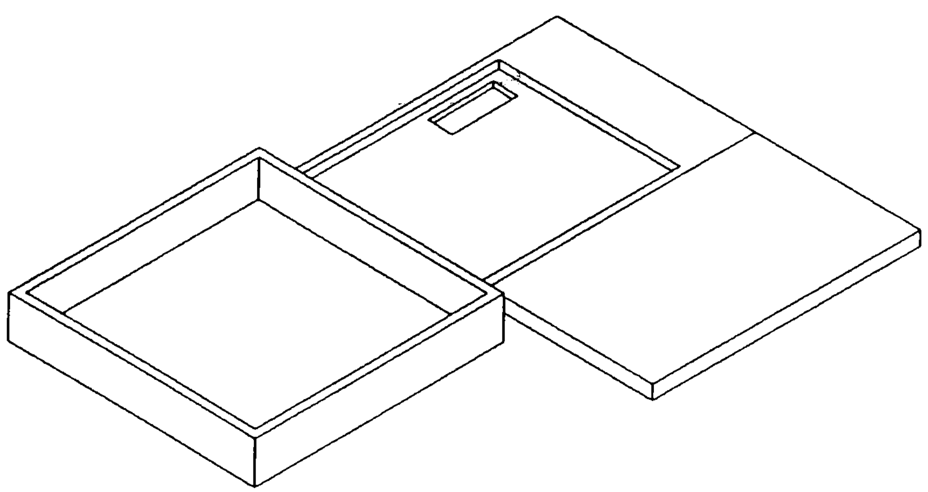
Rebar Detail

1" = 24"



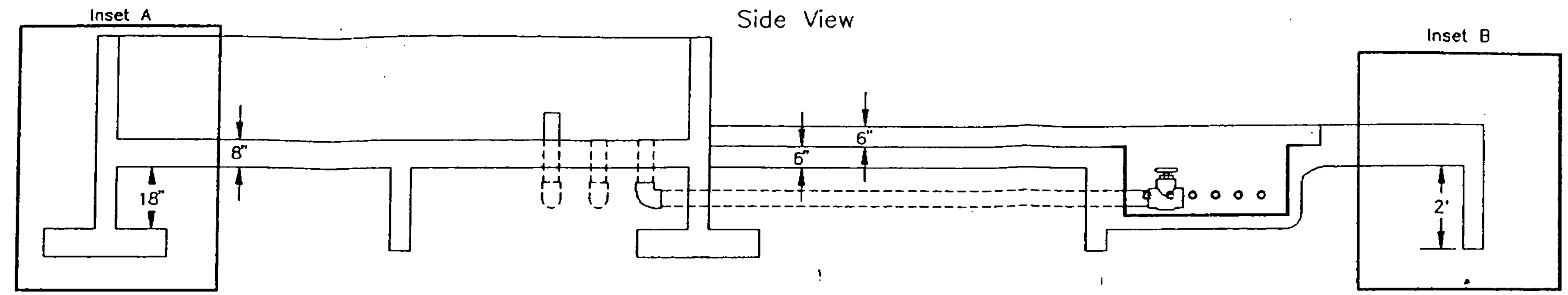
Isometric View

(Piping and Below Grade Not Shown)

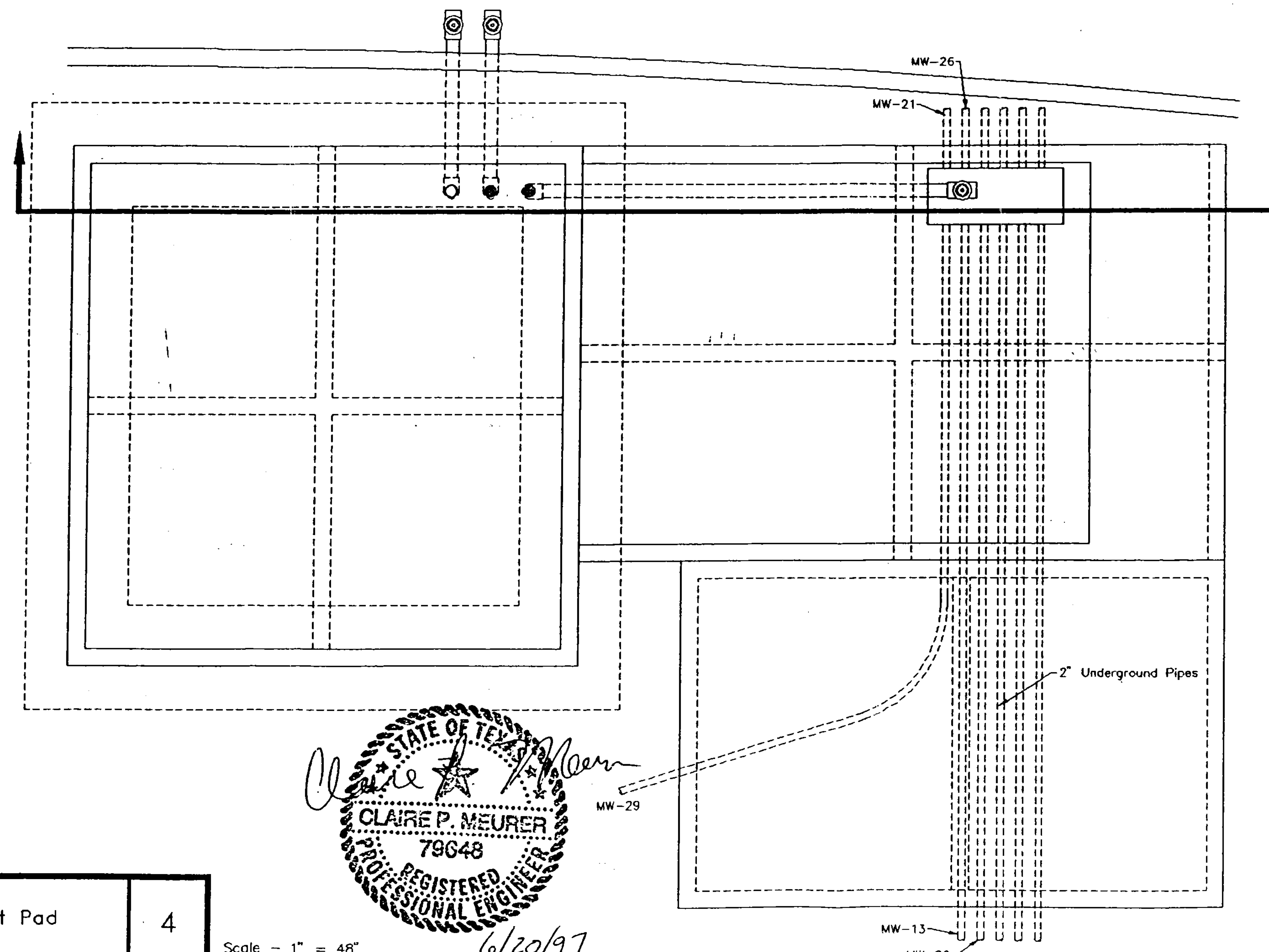


Scale – 1" = 120'

Side View



Plan View



Scale – 1" = 48'

APPLIED EARTH SCIENCES		Revised 10/18/96 Revised 10/30/96 Revised 02/12/97 Revised 06/05/97	Concrete Equipment Pad	4
03301-1	T. Gibson 10-09-96 Ref.File 033011			

Screwed Brass Orifices (SBO)—SCFH Air Flow in Hundreds

Pipe Size N.P.T.	Model Number	Pressure Drop, "W.C. 1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	12.0	14.0	16.0	18.0	20.0	Beta Ratio	Head Loss
1/2"	SBO-G-3	0.33	0.46	0.56	0.65	0.73	0.80	0.86	0.92	0.98	1.03	1.13	1.22	1.30	1.38	1.45	0.226	89%
1/2"	SBO-H-1	0.54	0.76	0.94	1.08	1.21	1.32	1.43	1.53	1.62	1.71	1.87	2.02	2.16	2.29	2.41	0.297	87%
1/2"	SBO-I-5	0.87	1.22	1.50	1.73	1.93	2.12	2.29	2.45	2.60	2.74	3.00	3.24	3.46	3.67	3.87	0.369	85%
1/2"	SBO-J-7	2.14	3.02	3.70	4.27	4.77	5.23	5.65	6.04	6.41	6.75	7.40	7.99	8.54	9.06	9.55	0.523	73%
1/2"	SBO-F-1	3.60	5.09	6.24	7.20	8.05	8.82	9.52	10.18	10.80	11.38	12.47	13.47	14.40	15.27	16.10	0.595	63%
3/4"	SBO-K-1	0.16	0.22	0.27	0.31	0.35	0.38	0.41	0.44	0.47	0.49	0.54	0.58	0.62	0.66	0.69	0.111	90%
3/4"	SBO-J-3	0.31	0.44	0.54	0.62	0.69	0.76	0.82	0.88	0.93	0.98	1.07	1.16	1.24	1.32	1.39	0.166	90%
3/4"	SBO-A-1	0.52	0.73	0.89	1.03	1.15	1.26	1.36	1.46	1.55	1.63	1.78	1.93	2.06	2.18	2.30	0.222	89%
3/4"	SBO-B-5	0.82	1.15	1.41	1.63	1.82	2.00	2.16	2.31	2.45	2.53	2.82	3.05	3.26	3.46	3.64	0.275	87%
3/4"	SBO-C-3	1.19	1.68	2.06	2.38	2.66	2.91	3.15	3.37	3.57	3.76	4.12	4.45	4.76	5.05	5.32	0.333	85%
3/4"	SBO-D-7	1.65	2.33	2.86	3.30	3.69	4.04	4.37	4.67	4.95	5.22	5.72	6.17	6.60	7.00	7.38	0.391	83%
1"	SBO-X-1	1.59	2.25	2.75	3.18	3.56	3.89	4.21	4.50	4.77	5.03	5.51	5.95	6.36	6.75	7.11	0.417	80%
1"	SBO-B-9	2.75	3.88	4.75	5.49	6.14	6.72	7.26	7.76	8.24	8.63	9.51	10.27	10.98	11.65	12.28	0.456	79%
1"	SBO-C-5	3.48	4.92	6.03	6.96	7.78	8.52	9.21	9.84	10.44	11.00	12.06	13.02	13.92	14.76	15.56	0.488	76%
1"	SBO-D-11	4.50	6.36	7.79	9.00	10.06	11.02	11.91	12.73	13.50	14.23	15.59	16.84	18.00	19.09	20.12	0.539	73%
1"	SBO-E-3	5.76	8.15	9.98	11.52	12.88	14.11	15.24	16.29	17.28	18.21	19.95	21.55	23.04	24.44	25.76	0.585	65%
1"	SBO-F-13	7.20	10.18	12.47	14.40	16.10	17.64	19.05	20.36	21.60	22.77	24.94	26.94	28.80	30.55	32.20	0.632	58%
1-1/4"	SBO-396	2.90	4.09	5.01	5.79	6.47	7.09	7.66	8.19	8.69	9.15	10.03	10.83	11.58	12.28	12.95	0.396	82%
1-1/4"	SBO-478	4.38	6.19	7.59	8.76	9.79	10.73	11.59	12.39	13.14	13.85	15.17	16.39	17.52	18.58	19.59	0.478	76%
1-1/4"	SBO-585	7.00	9.90	12.12	14.00	15.65	17.15	18.52	19.80	21.00	22.14	24.25	26.19	28.00	29.70	31.30	0.585	65%
1-1/4"	SBO-667	10.30	14.57	17.84	20.60	23.03	25.23	27.25	29.13	30.90	32.57	35.68	38.54	41.20	43.70	46.06	0.667	55%
1-1/2"	SBO-440	3.55	5.02	6.15	7.10	7.94	8.70	9.39	10.04	10.65	11.23	12.30	13.28	14.20	15.06	15.88	0.440	78%
1-1/2"	SBO-559	8.06	11.40	13.96	16.12	18.02	19.74	21.32	22.80	24.18	25.49	27.92	30.16	32.24	34.20	36.05	0.559	67%
1-1/2"	SBO-628	10.84	15.33	18.78	21.68	24.24	26.55	28.68	30.66	32.52	34.28	37.55	40.56	43.36	45.99	48.48	0.628	58%
1-1/2"	SBO-685	13.80	19.52	23.90	27.60	30.86	33.80	36.51	39.03	41.40	43.64	47.80	51.63	55.20	58.55	61.72	0.685	47%
1-1/2"	SBO-722	16.80	23.76	29.10	33.60	37.57	41.15	44.45	47.52	50.40	53.13	58.20	62.86	67.20	71.28	75.13	0.722	42%
2"	SBO-369	6.50	9.19	11.26	13.00	14.53	15.92	17.20	18.38	19.50	20.55	22.52	24.32	26.00	27.58	29.07	0.369	84%
2"	SBO-448	7.94	11.23	13.75	15.88	17.75	19.45	21.01	22.46	23.82	25.11	27.50	29.71	31.76	33.69	35.51	0.448	78%
2"	SBO-551	12.59	17.80	21.80	25.17	28.14	30.83	33.30	35.60	37.76	39.80	43.60	47.09	50.34	53.39	56.28	0.551	68%
2"	SBO-621	16.89	23.88	29.25	33.77	37.76	41.36	44.67	47.76	50.66	53.40	58.49	63.18	67.54	71.64	75.51	0.621	60%
2"	SBO-677	23.50	33.23	40.70	47.00	52.55	57.56	62.18	66.47	70.50	74.31	81.41	87.93	94.00	99.70	105.10	0.677	48%

Carbon Steel Orifices (CO)—SCFH Air Flow in Thousands

Pipe Size N.P.T.	Model Number	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	12.0	14.0	16.0	18.0	20.0	Beta Ratio	Head Loss
2-1/2"	CO-708-2.5	2.94	4.16	5.09	5.88	6.57	7.20	7.78	8.32	8.82	9.30	10.18	11.00	11.76	12.47	13.15	0.708	45%
2-1/2"	CO-810-2.5	4.44	6.28	7.69	8.88	9.93	10.88	11.75	12.56	13.32	14.04	15.38	16.61	17.76	18.84	19.86	0.810	20%
3"	CO-653-3	3.65	5.16	6.32	7.30	8.16	8.94	9.66	10.32	10.95	11.54	12.64	13.66	14.60	15.49	16.32	0.653	57%
3"	CO-734-3	4.98	7.04	8.63	9.96	11.14	12.20	13.18	14.09	14.94	15.75	17.25	18.63	19.92	21.13	22.27	0.734	40%
3"	CO-794-3	6.42	9.08	11.12	12.84	14.36	15.73	16.99	18.16	19.26	20.30	22.24	24.02	25.68	27.24	28.71	0.794	30%
4"	CO-619-4	5.64	7.98	9.77	11.28	12.61	13.82	14.92	15.95	16.92	17.84	19.54	21.10	22.56	23.93	25.22	0.619	60%
4"	CO-712-4	8.04	11.37	13.93	16.08	17.98	19.69	21.27	22.74	24.12	25.42	27.85	30.08	32.16	34.11	35.96	0.712	45%
4"	CO-804-4	11.52	16.29	19.95	23.04	25.76	28.22	30.48	32.58	34.56	36.43	39.91	43.10	46.08	48.88	51.52	0.804	22%
5"	CO-750-5	14.65	20.72	25.37	29.30	32.76	35.89	38.76	41.44	43.95	46.33	50.75	54.82	58.60	62.15	65.52	0.750	32%
6"	CO-575-6	11.00	15.56	19.05	22.00	24.60	26.94	29.10	31.11	33.00	34.79	38.11	41.16	44.00	46.67	49.19	0.575	66%
6"	CO-750-6	21.00	29.70	36.37	42.00	46.96	51.44	55.56	59.40	63.00	66.41	72.75	78.57	84.00	89.10	93.91	0.750	32%
8"	CO-800-8	45.00	63.64	77.94	90.00	100.62	110.23	119.06	127.28	135.00	142.30	155.88	168.37	180.00	190.92	201.25	0.800	25%
10"	CO-775-10	62.50	88.39	108.25	125.00	139.75	153.09	165.36	176.78	187.50	197.64	216.51	233.85	250.00	265.17	279.51	0.775	28%
12"	CO-792-12	96.00	135.76	166.28	192.00	214.66	235.15	253.99	271.53	288.00	303.58	332.55	359.20	384.00	407.29	429.33	0.792	25%
14"	CO-800-14	120.00	169.71	207.85	240.00	268.33	293.94	317.49	339.41	360.00	379.47	415.69	449.00	480.00	509.12	536.66	0.800	25%
16"	CO-800-16	158.50	224.15	274.53	317.00	354.42	388.24	419.35	448.31	475.50	501.22	549.06	593.05	634.00	672.46	708.83	0.800	25%
18"	CO-800-18	204.00	288.50	353.34	408.00	456.16	499.70	539.73	577.00	612.00	645.10	706.68	763.30	816.00	865.50	912.32	0.800	25%
20"	CO-800-20	252.00	356.38	436.48	504.00	563.49	617.27	666.73	712.76	756.00	796.89	872.95	942.90	1008.00	1069.15	1126.98	0.800	25%
24"	CO-800-24	354.00	500.63	613.15	708.00	791.57	867.12	936.60	1001.26	1062.00	1119.45	1226.29	1324.55	1416.00	1501.89	1583.14	0.800	25%

Beta ratio is the ratio of orifice diameter to pipe I.D.

Head loss is the pressure loss caused by the orifice as a percentage of the measured pressure drop.

Installation practices can affect accuracy. See page 4 for installation recommendations.

Correction Factors

To correct for specific gravity ONLY:

Multiply the flow from the table by:

Natural gas, .60 s.g.:	**1.29**
Propane, 1.56 s.g.:	**.80**
Butane, 2.00 s.g.:	**.71**
Propane/Air, 1.29 s.g.:	**.88**
Coke Oven, .45 s.g.:	**1.49**

To correct for any conditions:

Flows in the table are for air (1.0 s.g.) at 60° F., sea level (14.7 PSIA), with a supply pressure to the orifice of 1 PSIG. To correct for other conditions, use the following formula:

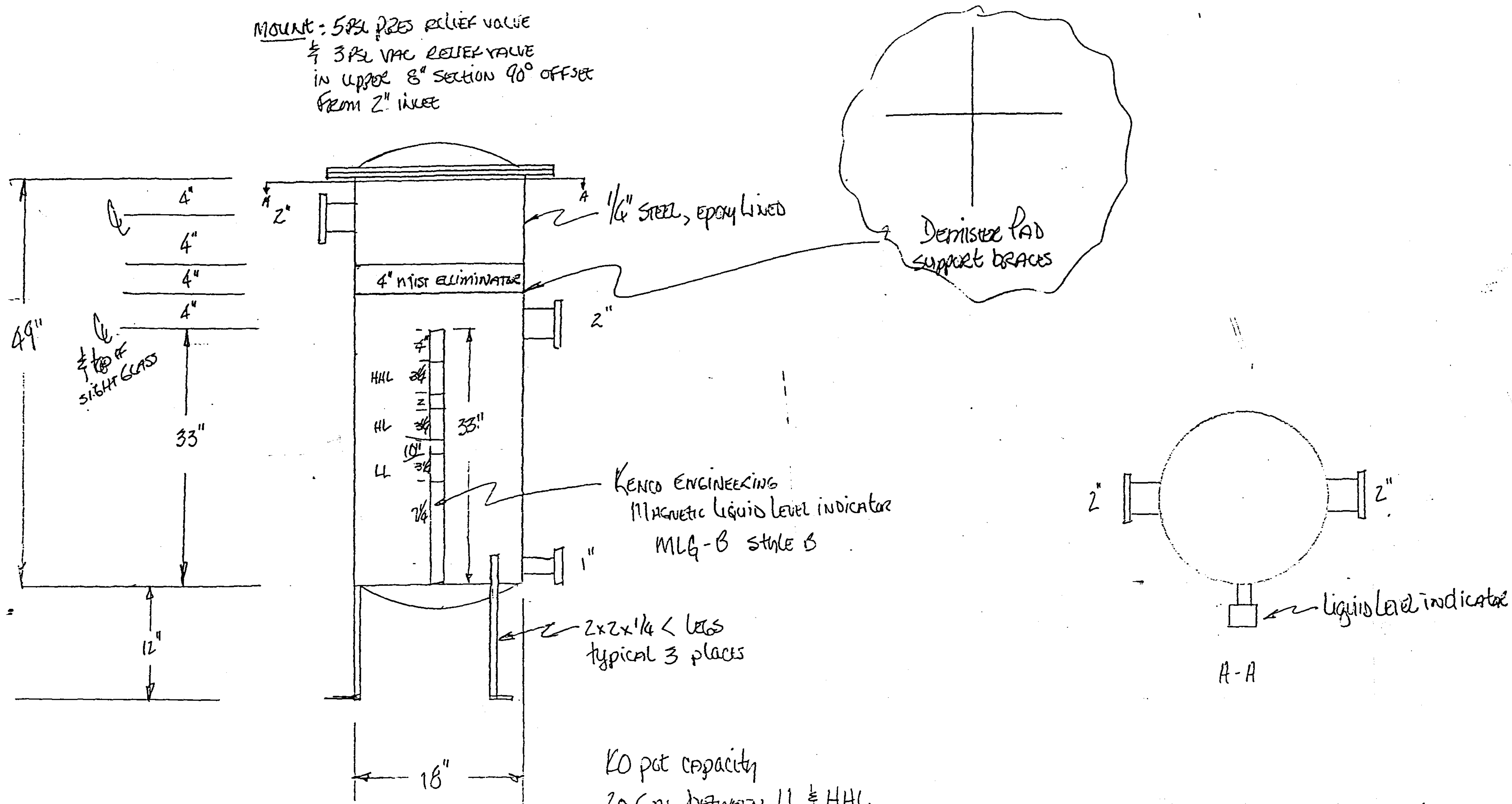
Corrected Flow =

$$\text{Flow From Table} \times \sqrt{\frac{520}{460^\circ + {}^\circ F} \times \frac{1}{S.G.} \times \frac{PSIA + PSIG}{15.7}}$$

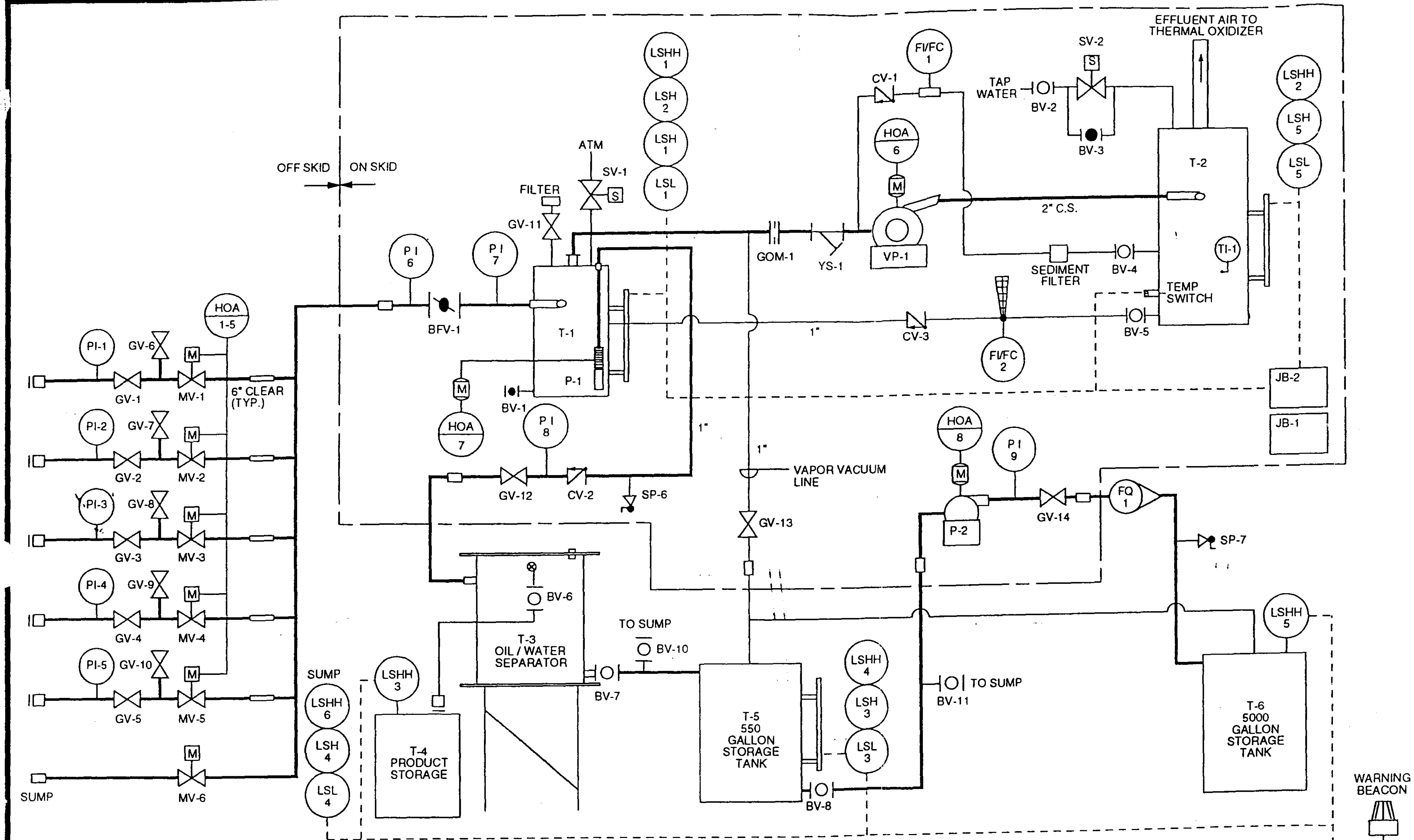
Where °F = Gas temp. through orifice
S.G. = Specific gravity of gas
PSIA = Barometeric pressure
PSIG = Supply pressure to orifice

Use these figures to estimate barometric pressure at various altitudes:

Sea Level	14.7 PSIA
1000'	14.2 PSIA
2000'	13.7 PSIA
3000'	13.2 PSIA
4000'	12.7 PSIA
5000'	12.2 PSIA
6000'	11.8 PSIA
7000'	11.3 PSIA



designed to operate on 120V 60Ø 1 phase
designed to withstand 3 & 5 PSI but not fabricated by code shop.
Unit #969



FP-1
PROGRAMMABLE LOGIC CONTROLLER
VP-1 MAGNETIC MOTOR STARTER
P-1 MAGNETIC MOTOR STARTER
P-2 MAGNETIC MOTOR STARTER
TEL-10 AUTODIALER
SURGE PROTECTOR

NOTE:
A) SYSTEM AIR FLOW RATE IS 75 CFM @ 25"Hg
B) SYSTEM WATER FLOW RATE IS 15 GPM
C) NEMA 4 CONTROLS OFF SKID
D) 4' X 8' SKID
E) ALL PROCESS PIPING IS 2" SCH80 PVC UNLESS OTHERWISE NOTED
F) CV-3 IS A SPRING LOADED CHECK VALVE THAT PREVENTS WATER LEVEL EQUALIZATION IF SYSTEM FAILS
G) OFF SKID PIPING BY OTHERS
H) 240 VAC, 1 PHASE POWER

DATE	BY	REVISION
6/2/97	DSH	B) ADD LSL-5, LSH-5, BV-10, BV-11 DELETE SP-1 THRU SP-5

NEPCCO

2140 N. E. 36TH AVE.
SUITE 100
OCALA, FL 34470

PREPARED FOR:
APPLIED EARTH SCIENCE

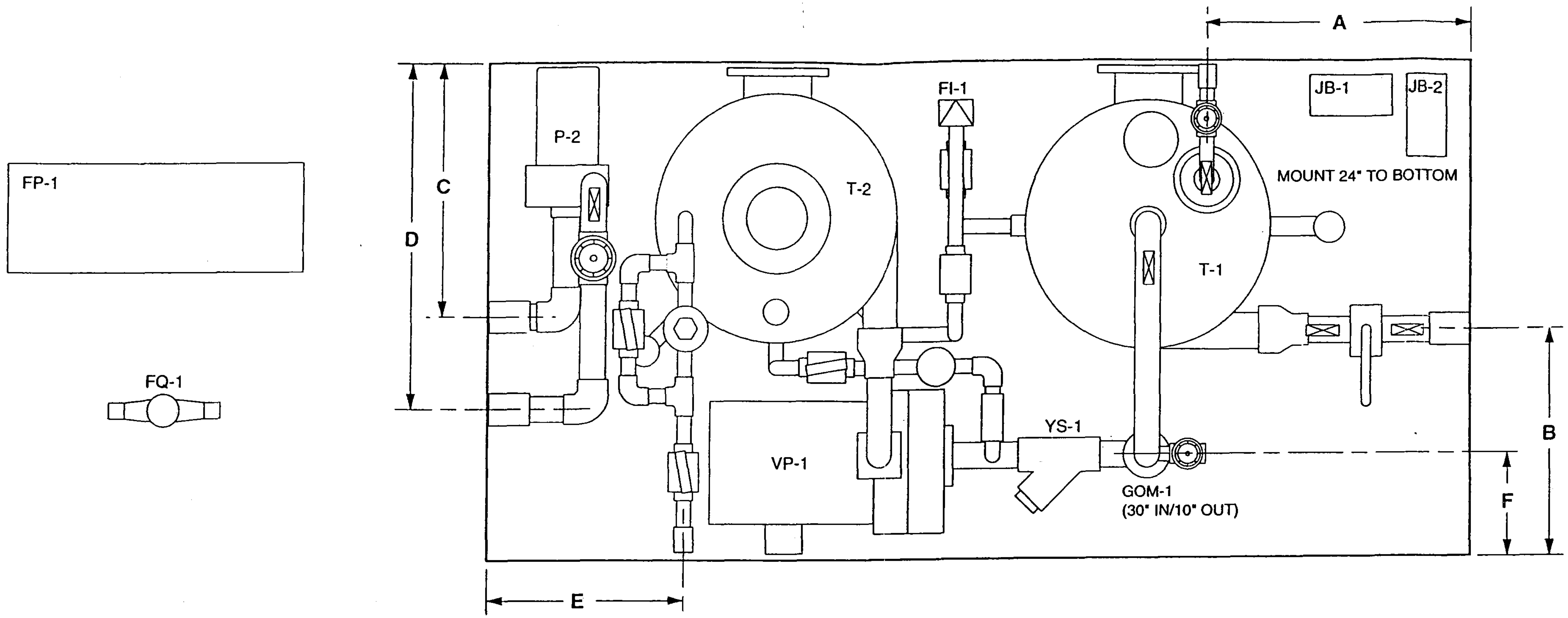
PROJECT NAME:

CUST. NUMBER
2430561601

TITLE:
P&ID

DRAWN BY:	CHECKED BY:
DH	KLR
ENG. APPROVAL	QA APPROVAL
RAM	CD
DATE: 12/2/96	SIZE B
DRAWING NO. 1028-2-01	SCALE NONE

SHEET 1 OF 9



1.) EFFLUENT **A** = 24 " AND EL = 68 " TO GRADE

2.) AIR INTAKE **B** = 19 " AND EL = 44 " TO GRADE

3.) INFLUENT **C** = 29 " AND EL = 8 " TO GRADE

4.) EFFLUENT **D** = 34 " AND EL = 19 " TO GRADE

5.) TAP WATER INLET **E** = 22 " AND EL = 60 " TO GRADE

6.) VAPOR INLET **F** = 8 " AND EL = 60 " TO GRADE

	L	W	H	DIA	HP	VAC	PHASE	GAL	CFM	GPM	NEMA	
SKID SIZE	8'	4'	4"									
CONTROLS						120	1				4	
AIR/WATER SEP(VACUUM)			48"	24"				70				
AIR/WATER SEP(SEAL WAT.)			54"	24"				70				
VACUUM PUMP VP-1					5	240	1		75		TEXP	
TRANSFER PUMP P-1					1 1/2	240	1			15		
TRANSFER PUMP P-2					1/2	240	1			20	TEXP	

LEGEND:

GATE VALVE
FLOW INDICATOR
PRESSURE GAGE
BALL VALVE
PARTICLE FILTER
CHECK VALVE
BUTTERFLY VALVE

DATE	BY	REVISION

NEPCCO

2140 N. E. 36TH AVE.
SUITE 100
OCALA, FL 34470

PREPARED FOR:
APPLIED EARTH SCIENCE

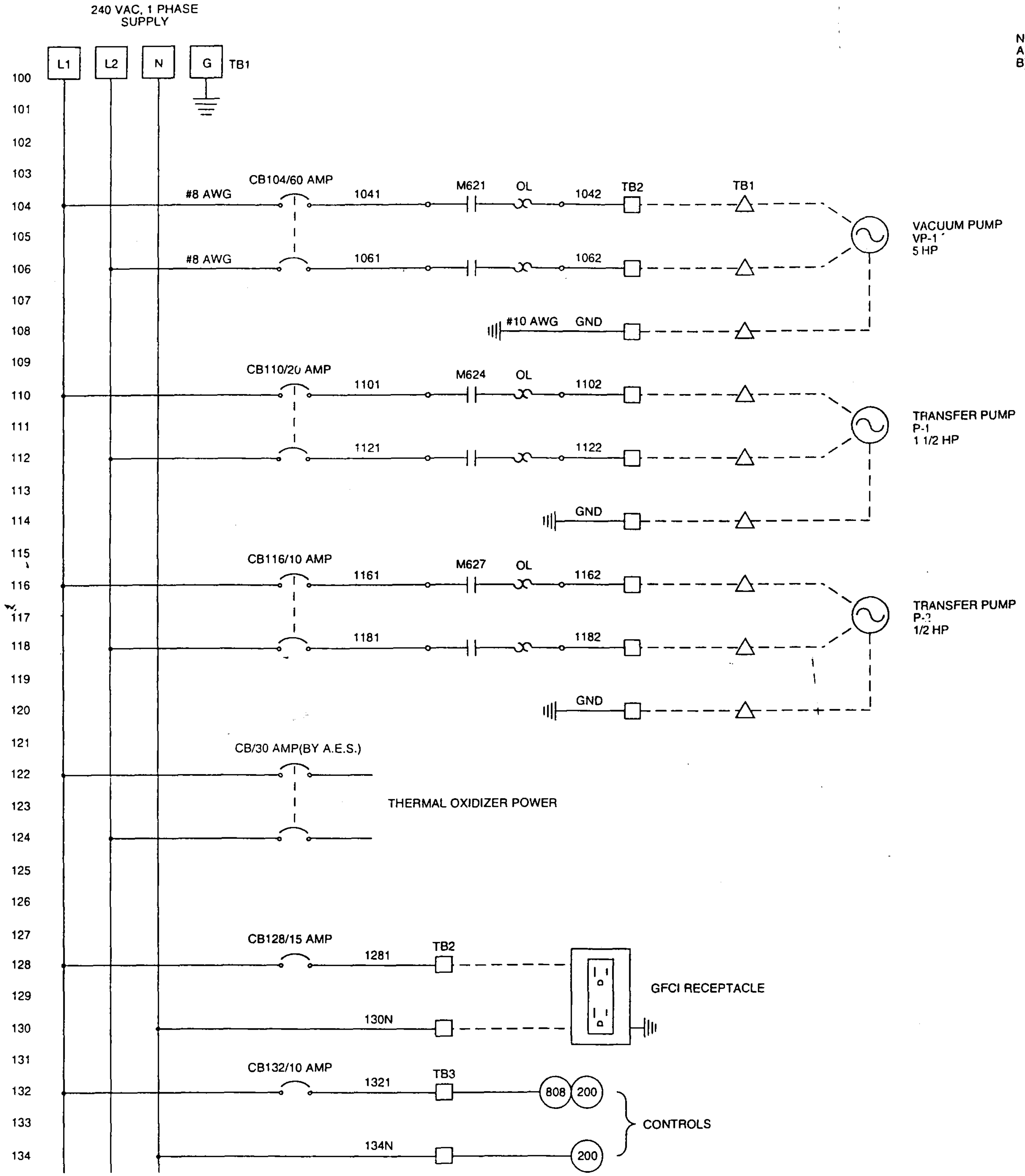
PROJECT NAME:
EMRO #60

CUST. NUMBER
2430561601

TITLE:
SVE AS BUILT LAYOUT

DRAWN BY:	CHECKED BY:
DH	
ENG. APPROVAL	QA APPROVAL
DATE: 12/2/96	SIZE B
DRAWING NO. 1028-4-01	SCALE 1" = 1'

SHEET 2 OF 9



NOTE:
A) POWER WIRING IS #12 AWG UNLESS OTHERWISE NOTED.
B) CONTROL WIRING IS #16 AWG UNLESS OTHERWISE NOTED.

LEGEND:

- □ TERMINAL IN FIELD PANEL FP-1
- △ TERMINAL IN JUNCTION BOX JB-1
- ⬡ TERMINAL IN JUNCTION BOX JB-2
- CIRCUIT BREAKER
- MOTOR OVERLOAD PROTECTOR
- FLOAT SWITCH
- TEMPERATURE SWITCH
- INDICATING LAMP
- COIL
- N.O. CONTACT
- N.C. CONTACT
- FIELD WIRING

DATE	BY	REVISION
7/14/97	DSH	B) ADD OXIDIZER POWER CIRCUIT BREAKER

NEPCCO

2140 N. E. 36TH AVE.
SUITE 100
OCALA, FL 34470

PREPARED FOR:
APPLIED EARTH SCIENCE

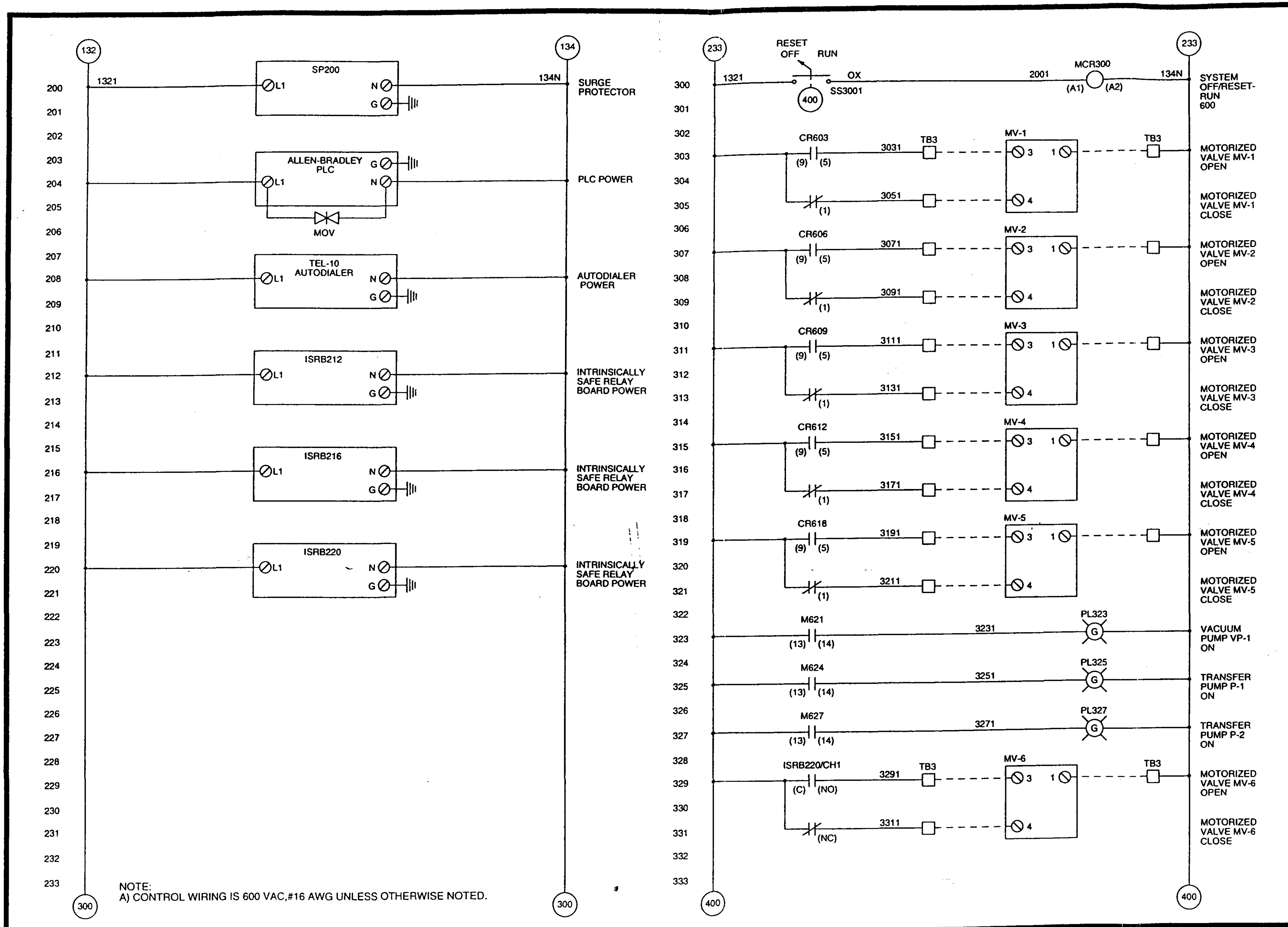
PROJECT NAME:

CUST. NUMBER
2430561601

TITLE:
LADDER LOGIC/ POWER WIRING DIAGRAM

DRAWN BY:	CHECKED BY:
DH	[signature]
ENG. APPROVAL	QA APPROVAL
[signature]	
DATE: 12/2/96	SIZE B
DRAWING NO. 1028-5-01	SCALE NONE

SHEET 3 OF 9



DATE	BY	REVISION

NEPCCO

2140 N. E. 36TH AVE.
SUITE 100
OCALA, FL 34470

PREPARED FOR:
APPLIED EARTH SCIENCE

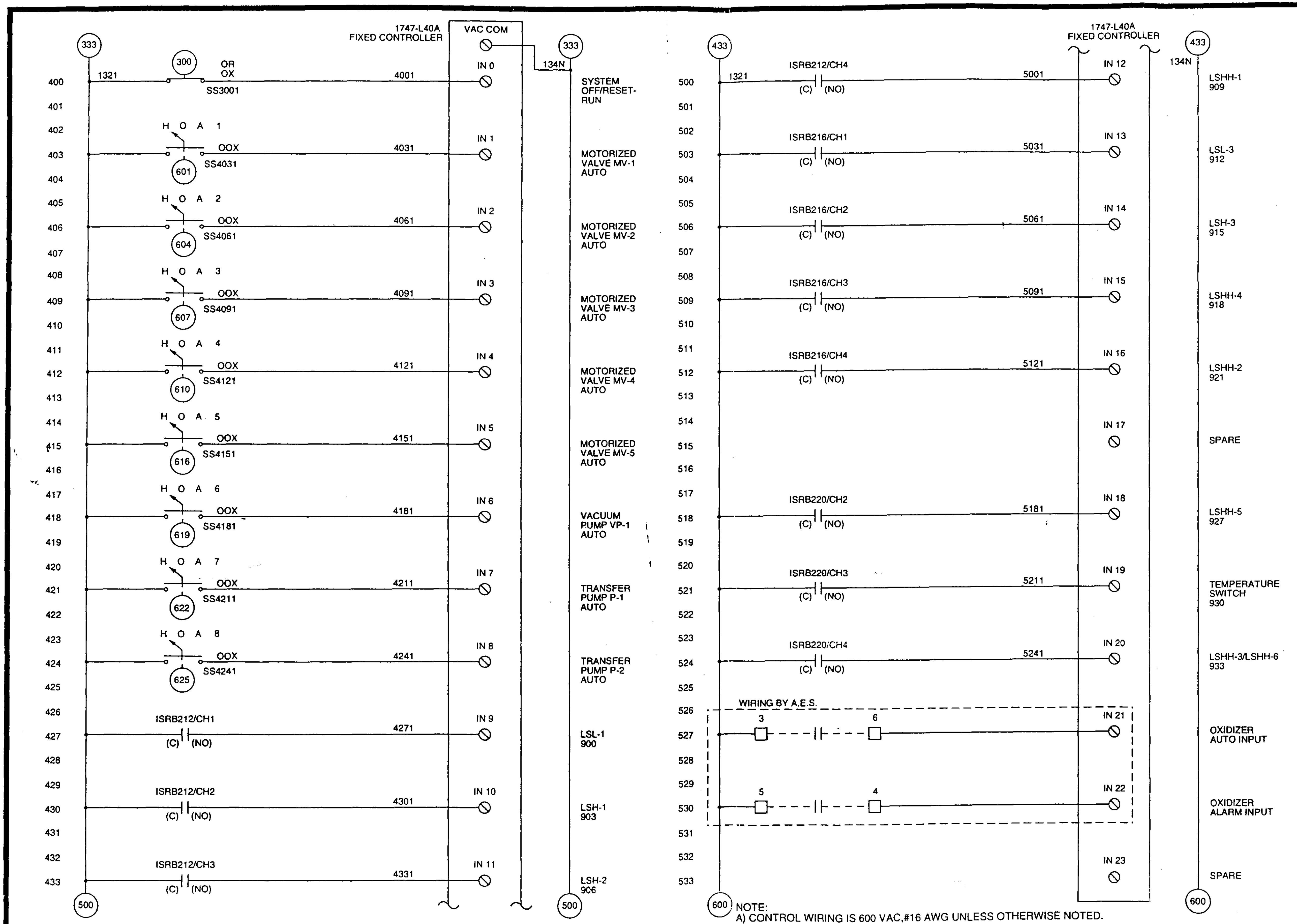
PROJECT NAME:

CUST. NUMBER
2430561601

TITLE:
LADDER LOGIC/ POWER WIRING DIAGRAM

DRAWN BY:	CHECKED BY:
DH	
ENG. APPROVAL	QA APPROVAL
DATE: 12/2/96	SIZE B
DRAWING NO. 1028-5-02	SCALE NONE

SHEET 4 OF 9



NOTE:
A) CONTROL WIRING IS 600 VAC,#16 AWG UNLESS OTHERWISE NOTED.

DATE	BY	REVISION
4/8/97	DSH	B) ADD OXIDIZER I/O

NEPCCO

2140 N. E. 36TH AVE.
SUITE 100
OCALA, FL 34470

PREPARED FOR: APPLIED EARTH SCIENCE

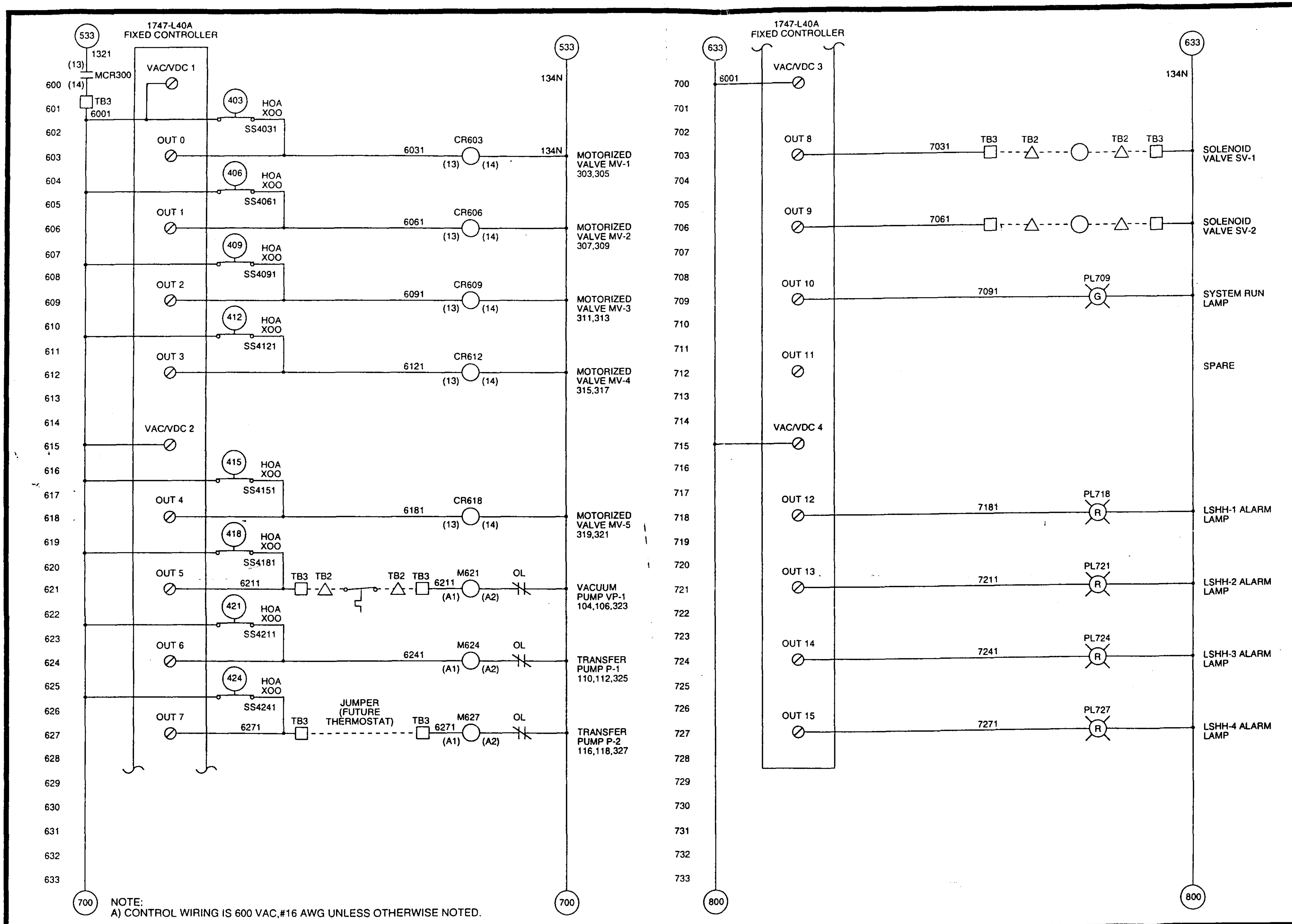
PROJECT NAME:

CUST. NUMBER: 2430561601

TITLE: LADDER LOGIC/ POWER WIRING DIAGRAM

DRAWN BY:	CHECKED BY:
DH	[signature]
ENG. APPROVAL	**QA APPROVAL**
RAM	
DATE: 12/2/96	**SIZE** B
DRAWING NO. 1028-5-03	**SCALE** NONE

SHEET 5 OF 9



DATE	BY	REVISION

NEPCCO

2140 N. E. 36TH AVE.
SUITE 100
OCALA, FL 34470

PREPARED FOR:
APPLIED EARTH SCIENCE

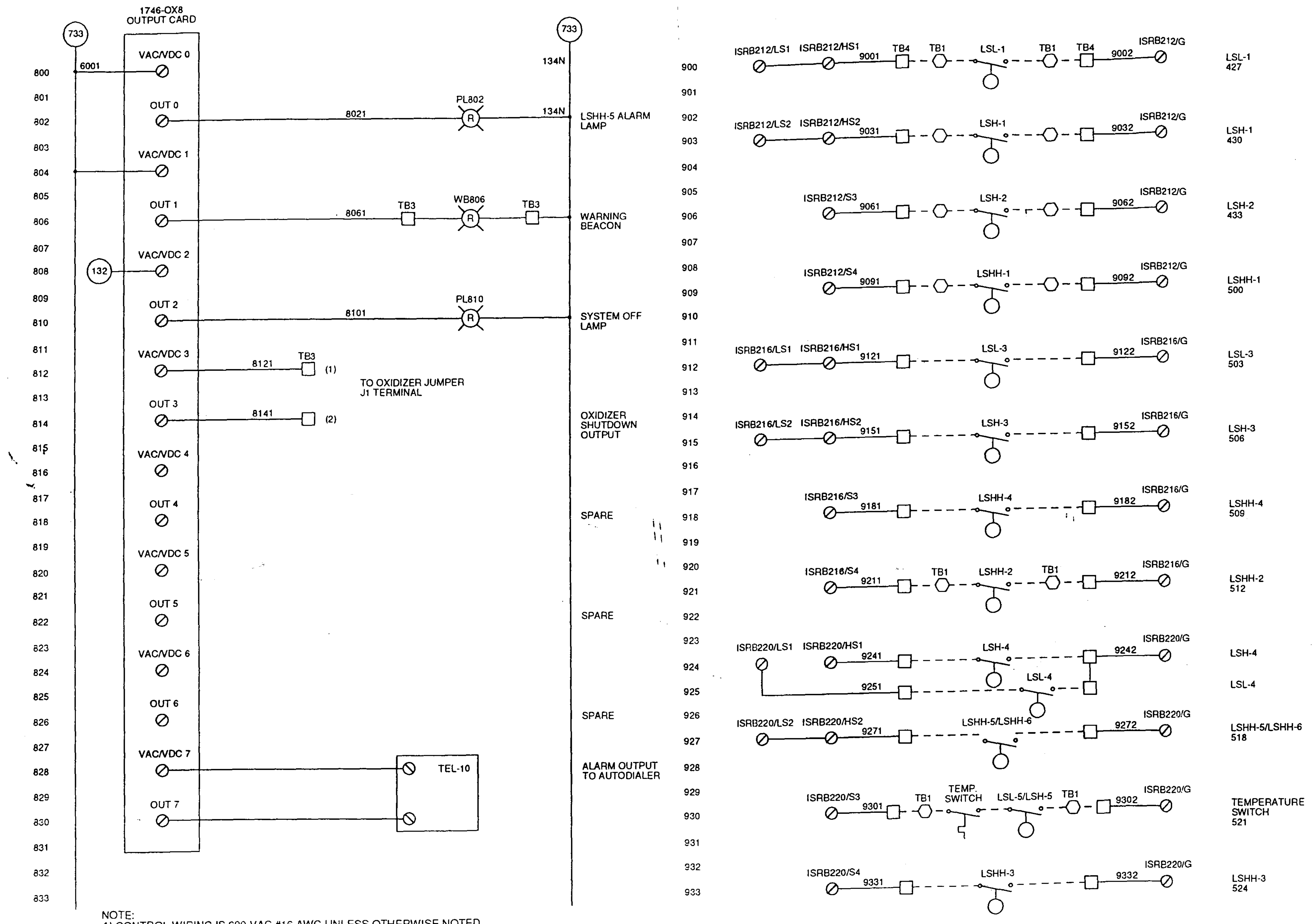
PROJECT NAME:

CUST. NUMBER
2430561601

TITLE:
LADDER LOGIC/ POWER WIRING DIAGRAM

DRAWN BY:	CHECKED BY:
DH	[signature]
ENG. APPROVAL	QA APPROVAL
[signature]	
DATE: 12/2/96	SIZE B
DRAWING NO. 1028-5-04	SCALE NONE

SHEET 6 OF 9



NOTE:
A) CONTROL WIRING IS 600 VAC,#16 AWG UNLESS OTHERWISE NOTED.

DATE	BY	REVISION
4/8/97	DSH	B) ADD OXIDIZER I/O
6/2/97	DSH	C) ADD LSL-5,LSH-5, LSHH-6

NEPCCO

2140 N. E. 36TH AVE.
SUITE 100
OCALA, FL 34470

PREPARED FOR:
APPLIED EARTH SCIENCE

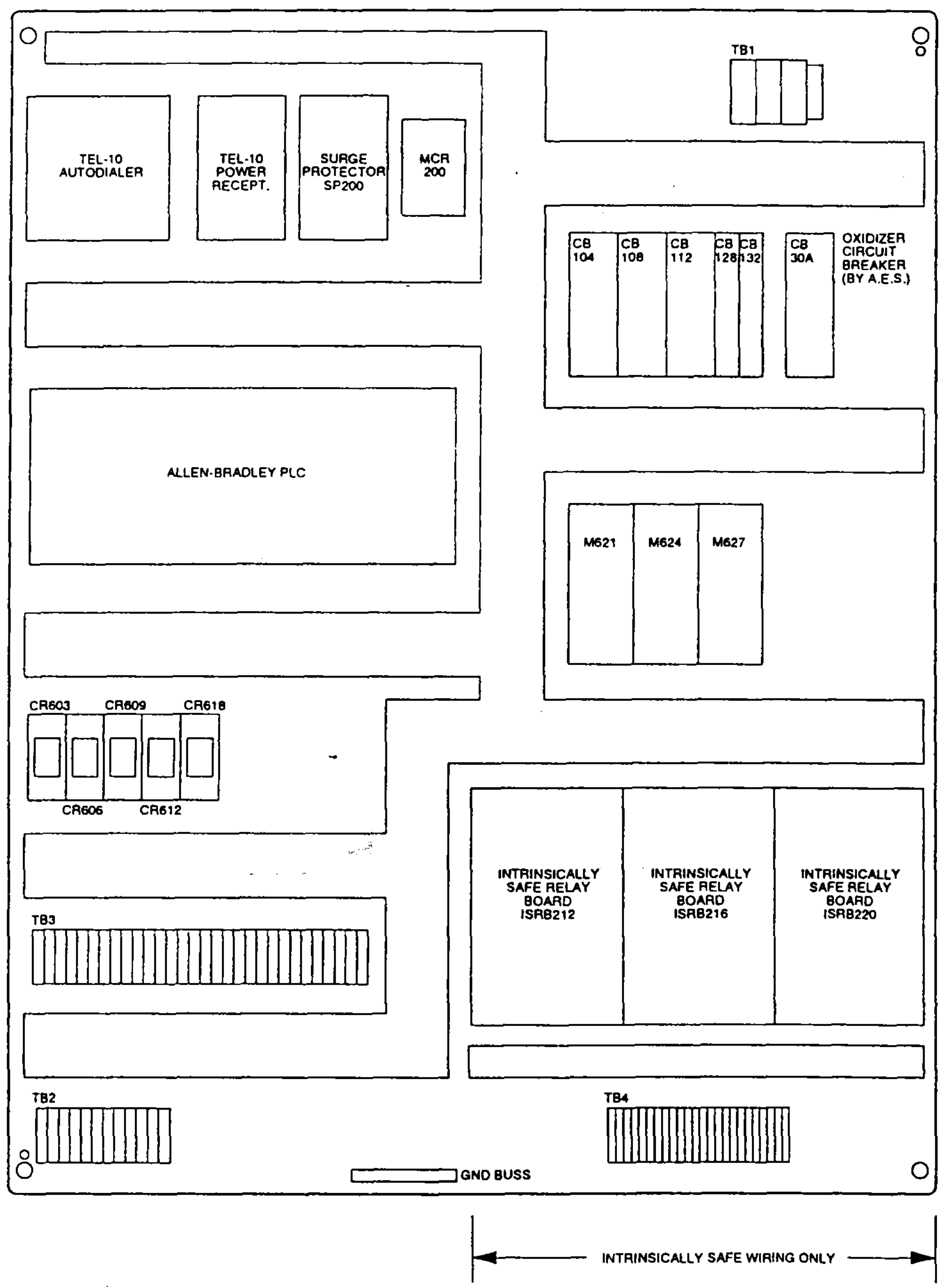
PROJECT NAME:

CUST. NUMBER
2430561601

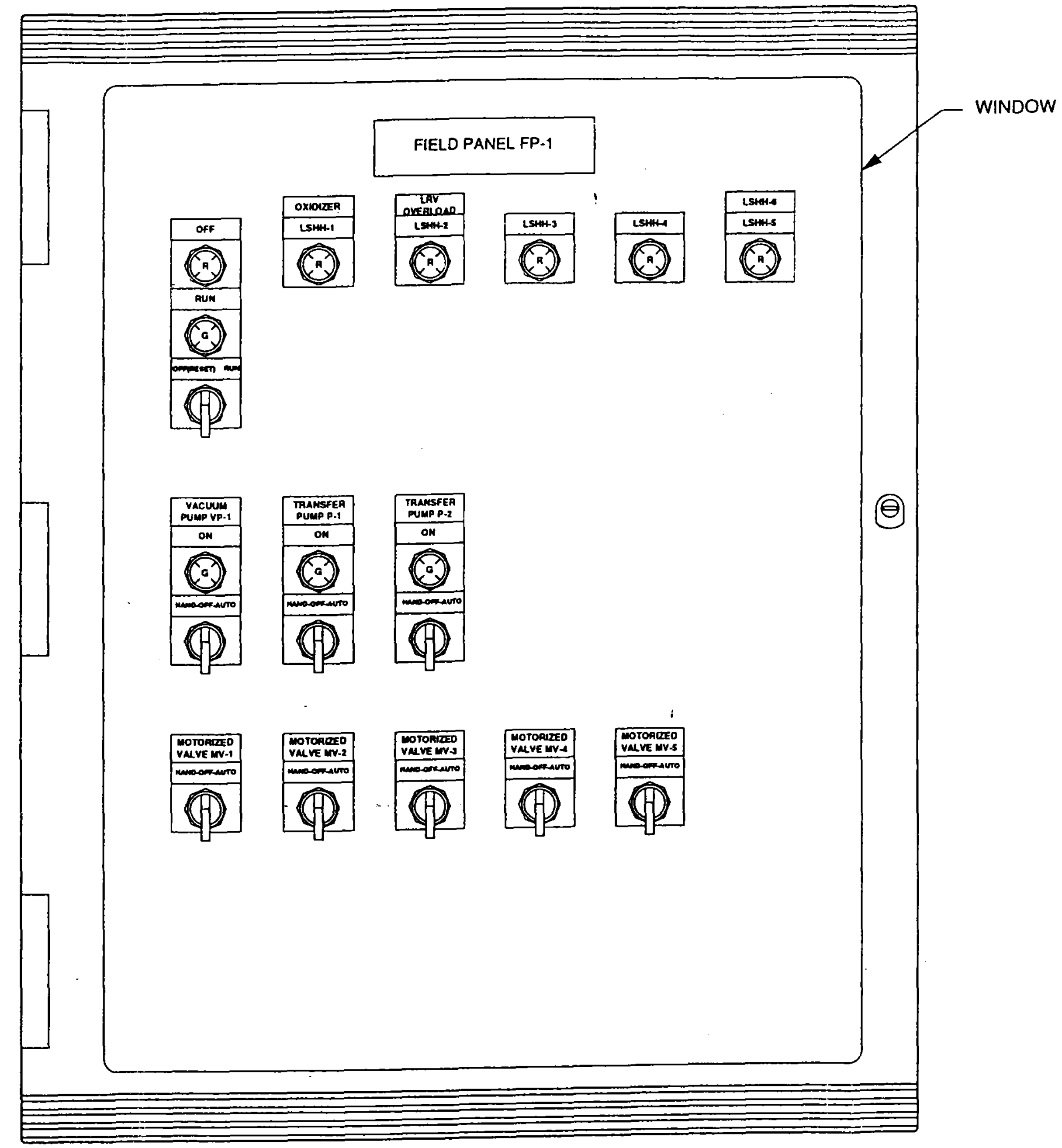
TITLE:
LADDER LOGIC/ POWER WIRING DIAGRAM

DRAWN BY:	CHECKED BY:
DH	KLR
ENG. APPROVAL	QA APPROVAL
[signature]	[signature]
DATE: 12/2/96	SIZE B
DRAWING NO. 1028-5-05	SCALE NONE

SHEET 7 OF 9



REAR PANEL LAYOUT



FRONT PANEL LAYOUT

DATE	BY	REVISION
4/8/97	DSH	B) ADD "OXIDIZER" LABEL
6/2/97	DSH	C) ADD "LRV OVERLOAD" LABEL
7/14/97	DSH	D) ADD "LSHH-6" LABEL, ADD OXIDIZER CIRCUIT BREAKER

NEPCCO

2140 N. E. 36TH AVE.
SUITE 100
OCALA, FL 34470

PREPARED FOR:
APPLIED EARTH SCIENCE

PROJECT NAME:

CUST. NUMBER
2430561601

TITLE:
FP-1 PANEL LAYOUT

DRAWN BY:	CHECKED BY:
DH	[signature]
ENG. APPROVAL	**QA APPROVAL**
[signature]	
DATE: 12/2/96	**SIZE** B
DRAWING NO. 1028-4-02	**SCALE** 1" = 6"

SHEET 8 OF 9

LOAD (240 VAC)	A PHASE	B PHASE	NEUTRAL
** VACUUM PUMP VP-1, 5 HP	35	35	
TRANSFER PUMP P-1, 1 1/2 HP	10	10	
TRANSFER PUMP P-2, 1/2 HP	4.9	4.9	
GFCI RECEPTACLE	5		5
CONTROLS	5		5
TOTAL	59.9	49.9	10

NOTE:
1) FULL LOAD AMPS ARE DERIVED FROM NEC TABLES 430-147 THROUGH 430-150 PER NEC 430-6a.
2) ** 1.25 TIMES LARGEST MOTOR FULL LOAD AMPS PER NEC 430-24.
3) MOTOR FEEDER CONDUCTORS SHALL BE SIZED PER NEC 430-24.
4) MOTOR FEEDER SHORT CIRCUIT PROTECTION SHALL BE SIZED PER NEC 430-62.

DATE	BY	REVISION

NEPCCO

2140 N. E. 36TH AVE.
SUITE 100
OCALA, FL 34470

PREPARED FOR: APPLIED EARTH SCIENCE

PROJECT NAME:

CUST. NUMBER: 2430561601

TITLE: LOAD SUMMARY

DRAWN BY: DH	CHECKED BY: KLR
ENG. APPROVAL: [signature]	QA APPROVAL: [signature]
DATE: 11/8/96	SIZE: B
DRAWING NO.: 1028-7-01	SCALE: NONE

SHEET 9 OF 9

PIPING

Major Process Line
Secondary Process Line
Air Line
Flange and Mate
Union
Orifice
Quick Disconnect
Reducer
Expansion Joint
Drain Plug
Diaphragm Isolator
Line list
Direction of Flow
Entry and Exit Flow

VALVES

B V	Ball Valve, Open
B V	Ball Valve, Closed
G L V	Globe Valve, Open
G L V	Globe Valve, Closed
C V	Check Valve
G V	Gate Valve, Open
G V	Gate Valve, Closed
B F V	Butterfly valve
S V	Solenoid Valve
S V	3 Way Solenoid Valve
S P	Sample Port

VALVES

P R V	Pressure Regulating Valve
S R V	Safety Relief Valve
V R V	Vacuum Relief valve
	Motorized Valve Actuator

PUMPS & BLOWERS

P	Transfer Pump
P	Pneumatic Submersible Pump
P	Electric Submersible Pump
P	Metering Pump
P	Double Diaphragm Pump
P	Gear Pump
P	Peristaltic Pump
B	Centrifugal Blower
B	Rotary Lobe Blower

DELIVERY AIR

COMPONENTS

	North Arrow
	Item Label
	Pitot Tube Velocity Measurement
P F	Particulate Filter Gas or Liquid
B S	Basket Strainer
A L	Alarm Light
	Flame Arrestor
M E	Mist Eliminator
	Muffler
A W S	Air Water Separator
F Q	In-Line Flow Totalizer
FI	Flow Indicator (Rotameter)
FI	Flow Indicator (vane)

ELECTRICAL

	Electrical Line
E I	Panel Light
H S, O O A	Hand Switch On / Off / Auto
	Field Device
F S,	Flow Sensor
LSHH,	Level Sensor HI - HI
LSH,	Level Sensor High
LSL,	Level Sensor Low
LSLL,	Level Sensor LO - LO
PI,	Pressure Indicator
PSHH,	Pressure Sensor HI - HI
PSLL,	Pressure LO - LO
PT,	Pressure Transmitter
dPI,	Differential Pressure Indicator
TI	Temperature Indicator

LABELS

G A C -	Granulated ActivatedCarbon
F I -	Flow Indicator
F P -	Field Panel
F S -	Flow Switch
F Q -	Flow Totalizer
I L K -	Sensor Interlock
M -	Motor
P D -	Power Disconnect
P E -	Pressure Element
P T -	Port Hole
T -	Tank
T M -	Telemanager

NEPCCO

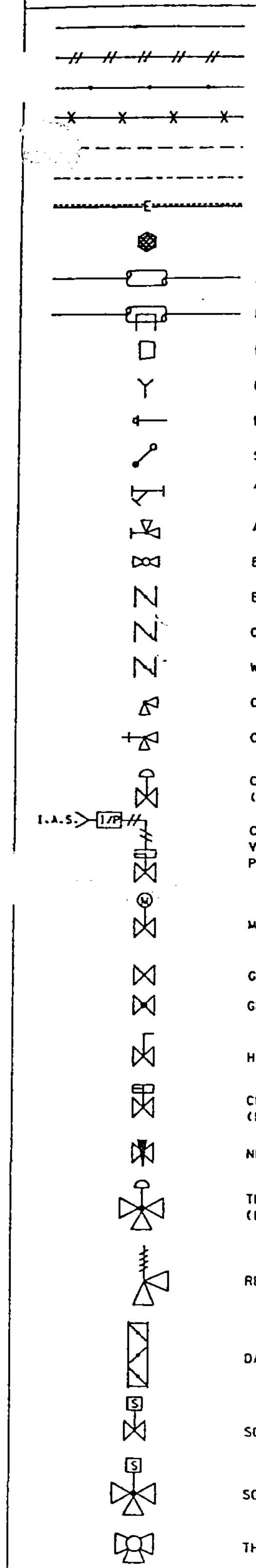
Title SYMBOLS AND ABBREVIATIONS

Dwg No ES-1-010-030 Date 12/20/95

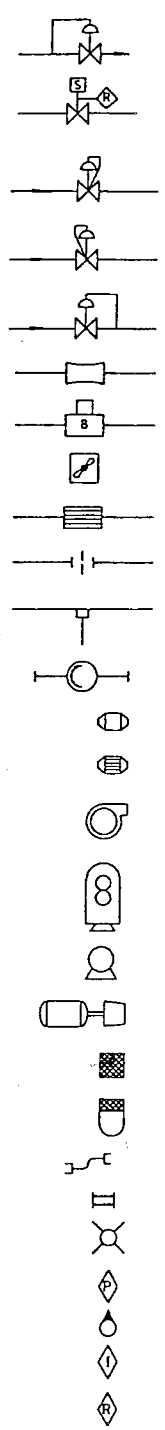
Approved Eng William M. Chamblin

Approved QA

SYMBOLS



- FLOW LINE
- TRANSMISSION LINE (PNEUMATIC)
- SUPPLY LINE (PNEUMATIC)
- CAPILLARY LINE
- ELECTRICAL SIGNAL
- MATCH LINE
- ELECTRIC HEAT TRACE
- FILTER REGULATOR
- INSULATION
- HEAT TRACE
- LINE SIZE CHANGE
- OPEN DRAIN SYSTEM
- LINE PLUG/CAP
- SPECTACLE BLIND
- "Y" STRAINER
- ANGLE VALVE
- BALL VALVE
- BUTTERFLY VALVE
- CHECK VALVE
- WAFER CHECK VALVE
- CHOKE VALVE (FIXED)
- CHOKE VALVE (ADJUSTABLE)
- CONTROL VALVE (DIAPHRAGM OPERATED)
- I.A.S. I/P — CONTROL VALVE WITH VALVE POSITIONER PNEUMATIC
- MOTOR OPERATED VALVE
- GATE VALVE
- GLOBE VALVE
- HAND CONTROL VALVE
- CONTROL VALVE (PNEUMATIC OPERATED)
- NEEDLE VALVE
- THREE-WAY CONTROL VALVE (DIAPHRAGM OPERATED)
- RELIEF VALVE
- DAMPER / LOUVER
- SOLENOID VALVE TWO-WAY
- SOLENOID VALVE THREE-WAY
- THREE-WAY VALVE



- BACKPRESSURE REGULATOR WITH EXTERNAL PRESSURE TAP
- LATCH-TYPE SOLENOID ACTUATOR FOR MANUAL RESET
- PRESSURE REDUCING REGULATOR (SELF CONTAINED)
- BACKPRESSURE REGULATOR (SELF CONTAINED)
- PRESSURE REDUCING REGULATOR WITH EXTERNAL PRESSURE TAP
- FLOW ELEMENT VENTURI
- FLOW ELEMENT (TURBINE TYPE)
- FLOW ELEMENT (MAGNETIC TYPE)
- FLOW STRAIGHTENING VANES
- FLOW ELEMENT (ORIFICE TYPE)
- TEMPERATURE ELEMENT W/ WELL
- POSITIVE DISPLACEMENT METER
- FLAME ARRESTOR
- DETONATION ARRESTOR
- CENTRIFUGAL BLOWER
- POSITIVE DISPLACEMENT BLOWER
- LIQUID PUMP
- AIR COMPRESSOR
- FILTER
- FILTER/SILENCER
- FLEXIBLE HOSE
- EXPANSION JOINT
- INDICATING LIGHT
- PURGE DEVICE
- FLOW INDICATOR
- LOCAL INTERLOCK
- MANUAL RESET

ABBREVIATIONS

AAL	ANALYSIS ALARM LOW
AAH	ANALYSIS ALARM HIGH
AY	ANALYSIS RELAY
AE	ANALYSIS ELEMENT
AIC	ANALYSIS INDICATING CONTROLLER
AI	ANALYSIS INDICATOR
AIT	ANALYSIS INDICATING TRANSMITTER
AT	ANALYSIS TRANSMITTER
AR	ANALYSIS RECORDER
BA	BURNER ALARM
BE	BURNER ELEMENT
BS	BURNER SWITCH
FAL	FLOW ALARM LOW
FC	FLOW CONTROLLER
FCV	FLOW CONTROL VALVE
FE	FLOW ELEMENT
FI	FLOW INDICATOR
FIC	FLOW INDICATING CONTROLLER
FR	FLOW RECORDER
FRC	FLOW RECORDING CONTROLLER
FSH	FLOW SWITCH HIGH
FSL	FLOW SWITCH LOW
FT	FLOW TRANSMITTER
FX	FLOW STRAIGHTING VANES
FY	FLOW RELAY
FV	FLOW VALVE
FQR	FLOW TOTALIZING RECORDER (TICKET PRINTER)
HIC	HAND INDICATING CONTROLLER
HV	HAND VALVE
HS	HAND SWITCH
KC	TIME CONTROLLER
KIC	TIME INDICATING CONTROLLER
LAHH	LEVEL ALARM HIGH HIGH
LAH	LEVEL ALARM HIGH
LAL	LEVEL ALARM LOW
LALL	LEVEL ALARM LOW LOW
LC	LEVEL CONTROLLER
LCV	LEVEL CONTROL VALVE
LG	LEVEL GUAGE
LN	INTERFACE LEVEL GUAGE
LS	LEVEL SWITCH
LI	LEVEL INDICATOR
LIC	LEVEL INDICATING CONTROLLER
LSH	LEVEL SWITCH HIGH
LR	LEVEL RECORDER
LRC	LEVEL RECORDING CONTROLLER
LSHH	LEVEL SWITCH HIGH HIGH
LT	LEVEL TRANSMITTER
LSH/L	LEVEL SWITCH HIGH LOW
LV	LEVEL VALVE
LY	LEVEL RELAY
ME	MOISTURE ELEMENT
MI	MOISTURE INDICATOR
PE	PRESSURE ELEMENT
PAH	PRESSURE ALARM HIGH
PAHH	PRESSURE ALARM HIGH HIGH
PAL	PRESSURE ALARM LOW
PALL	PRESSURE ALARM LOW LOW
PC	PRESSURE CONTROLLER
PIC	PRESSURE INDICATING CONTROLLER
PCV	PRESSURE CONTROL VALVE
PDC	PRESSURE DIFFERENTIAL CONTROLLER
PDIC	PRESSURE DIFFERENTIAL INDICATING CONTROLLER
PDSH	PRESSURE DIFFERENTIAL SWITCH HIGH
PDI	PRESSURE DIFFERENTIAL INDICATOR
PDS	PRESSURE DIFFERENTIAL SWITCH
PI	PRESSURE INDICATOR
PDSL	PRESSURE DIFFERENTIAL SWITCH LOW
PR	PRESSURE RECORDER
PDT	PRESSURE DIFFERENTIAL TRANSMITTER
PRC	PRESSURE RECORDER CONTROLLER
PS	PRESSURE SWITCH
PSH	PRESSURE SWITCH HIGH
PSHH	PRESSURE SWITCH HIGH HIGH
PSL	PRESSURE SWITCH LOW
PSLL	PRESSURE SWITCH LOW LOW
PSE	PRESSURE SAFETY ELEMENT
PSV	PRESSURE SAFETY VALVE
PIT	PRESSURE INDICATING TRANSMITTER
PT	PRESSURE TRANSMITTER
PY	PRESSURE RELAY
TAH	TEMPERATURE ALARM HIGH
TAHH	TEMPERATURE ALARM HIGH HIGH
TAL	TEMPERATURE ALARM LOW
TALL	TEMPERATURE ALARM LOW LOW
TC	TEMPERATURE CONTROLLER
TCV	TEMPERATURE CONTROL VALVE
TE	TEMPERATURE ELEMENT
TI	TEMPERATURE INDICATOR
TIC	TEMPERATURE INDICATING CONTROLLER
TR	TEMPERATURE RECORDER
TS	TEMPERATURE SWITCH
TSH	TEMPERATURE SWITCH HIGH
TSL	TEMPERATURE SWITCH LOW
TT	TEMPERATURE TRANSMITTER
TW	TEMPERATURE WELL
ZSO	LIMIT SWITCH TO PROVE VALVE IN OPEN POSITION
ZSC	LIMIT SWITCH TO PROVE VALVE IN CLOSED POSITION
ZSL	LIMIT SWITCH TO PROVE VALVE IN MINIMUM STOP POSITION

ADDITIONAL INSTRUMENT ABBREVIATION, IF REQUIRED

THE FOLLOWING TABLE IS A GUIDE FOR ADDING ABBREVIATIONS

	USUAL OR PREFERRED USAGE			
	FIRST POSITION	SECOND POSITION	THIRD POSITION	FOURTH POSITION
A	ANALYSIS	ALARM	ALARM	
B	BURNER FLAME	USERS CHOICE	USERS CHOICE	USERS CHOICE
C	CONDUCTIVITY (ELECTRICAL)	CONTROL, CONTROLLER	CONTROLLER/CLOSED	CONTROLLER
D	DENSITY OR SPECIFIC GRAVITY	DIFFERENTIAL		
E	VOLTAGE (EMF)	ELEMENT	ELEMENT	
F	FLOW RATE	FRACTION (RATIO)		
G	GAGING (DIMENSIONAL)	GLASS		
H	HAND INITIATED		HIGH/RUNNING	HIGH
I	CURRENT (ELECTRICAL)	INDICATOR, INDICATING	INDICATOR, INDICATING	INDICATOR
J	POWER	SCAN		
K	TIME	CONTROL STATION	CONTROL STATION	
L	LEVEL	LIGHT (PILOT)	LOW/FAILURE	LOW
M	MOISTURE OR HUMIDITY			
N	USERS CHOICE			
O	USERS CHOICE	ORIFICE (RESTRICTED)	OPEN	
P	PRESSURE OR VACUUM	POINT (TEST CONNECTION)		
Q	QUANTITY OR EVENT	INTIGRATE (TOTALIZE)		
R	RADIOACTIVITY	RECORDER, RECORDING	RECORDER, RECORDING	RECORDER
S	SPEED OR FREQUENCY	SAFETY, SWITCH	SAFETY, SWITCH	
T	TEMPERATURE	TRANSMITTER	TRANSMITTER	
U	MULTIVARIABLE	MULTIFUNCTION		
V	VISCOSITY	VALVE	VALVE	VALVE
W	WEIGHT OR FORCE	WELL		
X	SHUTDOWN	UNCLASSIFIED	TELEMETRY/AUTODIALER	
Y	SYSTEM	RELAY	RELAY	
Z	POSITION	DRIVE, ACTUATE, ACTUATOR	DRIVE, ACTUATE, ACTUATOR	

GENERAL INSTRUMENT SYMBOL BALLOONS

(1)	(2)	(3)	(4)	(5)	(6)
LOCALLY MOUNTED	MOUNTED ON MAIN BOARD. BOARD 2 DESIGNATED BY A DASHED LINE.	MOUNTED BEHIND THE BOARD. BOARD 2 DESIGNATED BY DASHED LINES.	PLC FUNCTION		

INSTRUMENT FOR SINGLE MEASURED VARIABLE WITH ANY NUMBER OF FUNCTIONS. INSTRUMENT WITH TWO MEASURED VARIABLES AND OPTIONALLY SINGLE-VARIABLE INSTRUMENT WITH MORE THAN ONE FUNCTION. ADDITIONAL TANGENT BALLOONS MAY BE ADDED AS REQUIRED.

ABBREVIATIONS (OTHER THAN INSTRUMENTS)

A	ANALOG SIGNAL
ACR	AIR COMPRESSOR
AO	AIR TO OPEN
AC	AIR TO CLOSE
AS	AIR SUPPLY
BS&W	BASIC SEDIMENT AND WATER
CCS	CENTRAL CONTROL STATION
CPL	COUPLING
DA	DIRECT ACTING
DTA	DETONATION ARRESTOR
EJ	EXPANSION JOINT
ES	ELECTRICAL SUPPLY
ESD	EMERGENCY SHUT DOWN
FA	FLAME ARRESTOR
FB	FULL BORE
FL	FAIL LOCKED
FC	FAIL CLOSED
FO	FAIL OPEN
HOA	HAND/OFF/AUTO SWITCH
MOV	MOTOR OPERATED VALVE
MR	MANUAL RESET
MW	MANWAY
MCC	MOTOR CONTROL CENTER
NC	NORMALLY CLOSED
NO	NORMALLY OPEN
PB	PUSH BUTTON SWITCH
RA	REVERSE ACTING
RO	RESTRICTIVE ORIFICE
SC	SAMPLE CONNECTION
SDV	SHUT DOWN VALVE
STR	STRAINER
SP	SET POINT
SW	SWITCH
MA	MANUAL ACTUATOR
IAS	INSTRUMENT AIR SUPPLY
FR	FILTER REGULATOR

RELAY FUNCTION DESIGNATORS

A/D	ANALOG TO DIGITAL TRANSDUCER
D/A	DIGITAL TO ANALOG TRANSDUCER
E/I	VOLTAGE TO CURRENT TRANSDUCER
I/P	CURRENT TO PNUEMATIC TRANSDUCER
P/I	PNUEMATIC TO CURRENT TRANSDUCER
Σ	ADD OR TOTALIZE SIGNAL SUMMATION
√	SQUARE ROOT EXTRACTION
Δ	DIFFERENTIAL SUBTRACT
>	HIGH SELECT
<	LOW SELECT
X	MULTIPLIER

NOTES

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

NO.	DATE	BY	CHK'D	APP'D	REVISION
7	2/26/97	KUB		SH	ADD FILTER/SILENCER, PD BLOWER.
					CHANGE I/P PNEU. VALVE SYMBOL.
					INSTRUMENT SYMBOL BALLOON
6	1/29/96	RZP		RZP	ADD RUNNING AND FAILURE TO
					3RD POSITION
5	1/3/96	SH		SH	CHANGE 'X' TO TELEMETRY/AUTODIALER
					3RD POSITION
4	11/13/95	SH		SH	MOVED RELAY FUNCT & ADD LINE PLUG

DRAWN ALZ
DATE 2/16/95
SCALE NTS
CHECKED
APP'D

CUSTOMER
APPLIED EARTH SCIENCES

P&ID LEGEND

THERMTECH INC.
POLLUTION CONTROL SYSTEMS
KINGWOOD, TEXAS 1-800-659-8271

JOB NO 946
JOBSITE TX
REV NO 7
DWG NO 946PID
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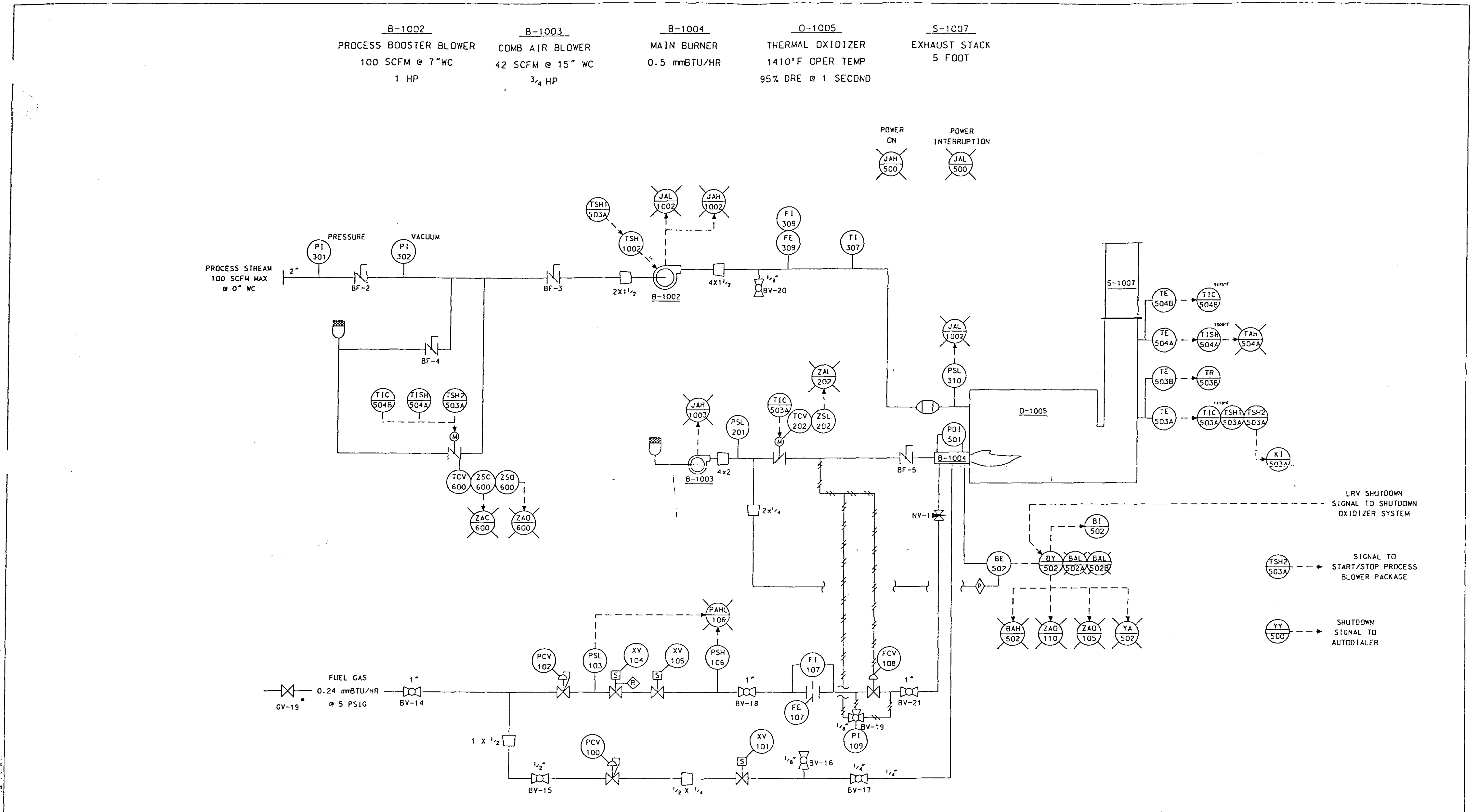

NOTES

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

* SUPPLIED BY CUSTOMER

SUPPLIED BY THERMTECH INC.
TO BE FIELD INSTALLED BY CUSTOMER

NO.	DATE	BY	CHK'D	APP'D	REVISION
1	5/13/97	DLN		SH	CHANGE VALVE #'S (CUSTOMER REQUEST), CHANGE B-1003 TO 42 SCFM & B-1004 TO 0.5 mm

DRAWN KUB
DATE 3/24/97
SCALE NTS
CHECKED
APP'D

CUSTOMER
APPLIED EARTH SCIENCES

VAC10 P&ID

THERMTECH INC.
POLLUTION CONTROL SYSTEMS
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JOB NO. 946
JOBSITE TX
REV NO. 1
DWG NO. 946PID
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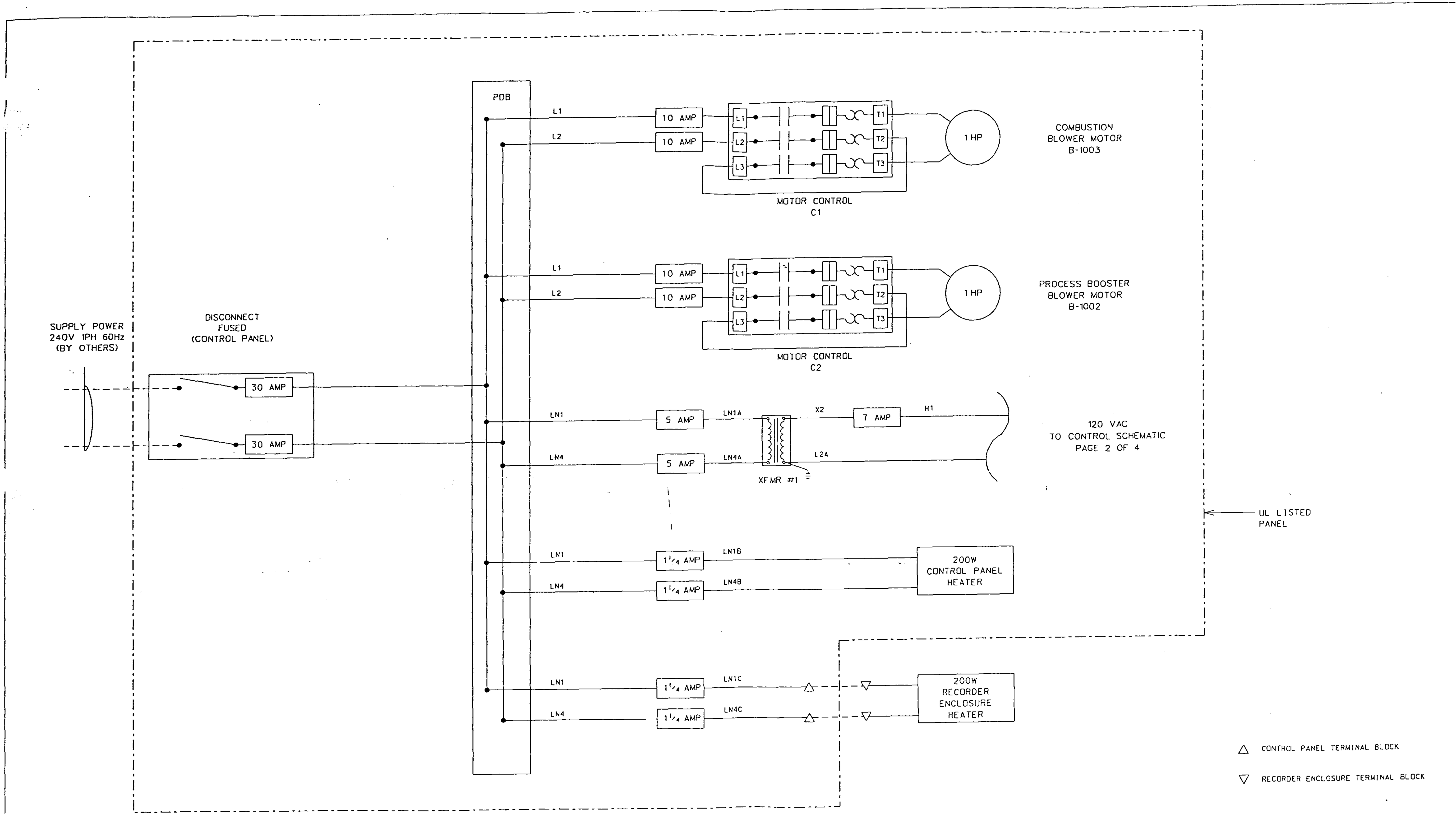

NOTES

1. SERVICE ENTRANCE TO BE THROUGH SIDE OF PANEL ENCLOSURE
2. ALL FIELD WIRING TO PANEL TO BE COPPER WIRE, 60C WIRE INSULATION FOR LESS THAN 100A AND 75C FOR 100A AND GREATER.
3. ALL BRANCH CIRCUITS ORIGINATE AT POWER DISTRIBUTION BLOCKS IN CONTROL PANEL

NO.	DATE	BY	CHK'D	APP'D	REVISION
2	5/13/97	DLN		SH	ADD CUSTOMER WIRE NUMBERS @ TERMINAL BLOCKS NOTE 1,2,3
1	4/10/97	KUB		SH	CHANGE PEN NO.'S ON TIC504B, LINE 81-84

CUSTOMER
APPLIED EARTH SCIENCES

DRAWN	KUB
DATE	3/24/97
SCALE	NTS
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ONE LINE DIAGRAM

THERMTECH INC.
POLLUTION CONTROL SYSTEMS
KINGWOOD, TEXAS 1-800-659-8271

JOB NO	946
JOBSITE	TX
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DWG NO	946ELE
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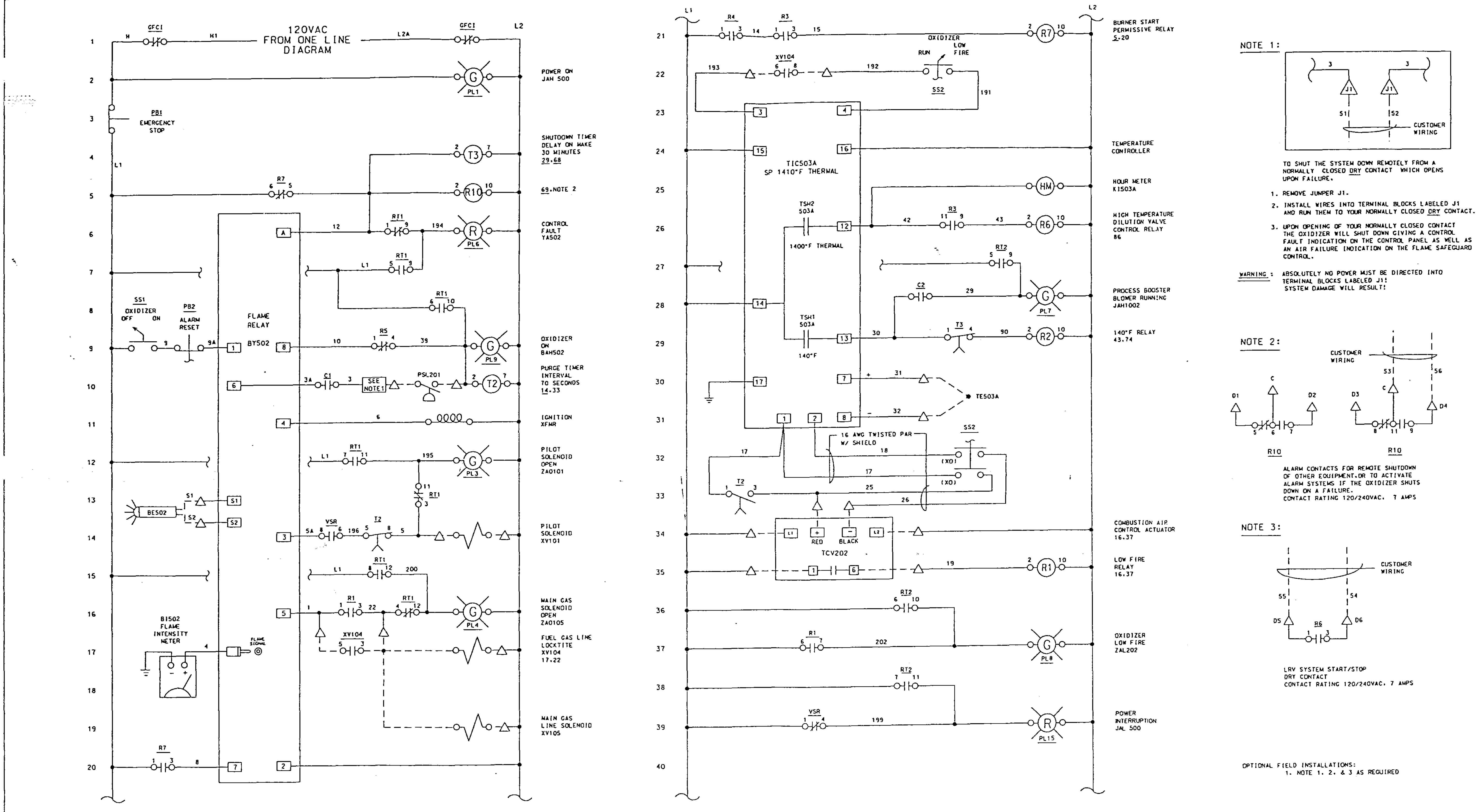

NOTES
1. TERMINAL BLOCK CONNECTORS TO BE TORQUED TO 6.2 in/lbs FOR FIELD WIRING.
2. ALL FIELD WIRING TO PANEL TO BE COPPER WIRE. 60°C WIRE INSULATION FOR LESS THAN 100A AND 75°C FOR 100A AND GREATER
3. CONTROL CIRCUIT FIELD WIRING TO BE 12-14 AWG WIRE

CONTROL PANEL TERMINAL BLOCK ▽ RECORDER ENCLOSURE TERMINAL BLOCK
WIRING OUTSIDE PANELS
* SUPPLIED BY CUSTOMER
** SUPPLIED BY THERMTECH. FIELD INSTALLED BY CUSTOMER

NO.	DATE	BY	CHK'D	APP'D	REVISION
2	5/13/97	DLN		SH	ADD CUSTOMER WIRE NUMBERS @ TERMINAL BLOCKS NOTE 1,2,3
1	4/10/97	KUB		SH	CHANGE PEN NO.'S ON TIC504B. LINE 81-84

DRAWN	KUB
DATE	3/24/97
SCALE	NTS
CHECKED	
APP'D	

CUSTOMER
APPLIED EARTH SCIENCES

CONTROL SCHEMATIC

THERMTECH INC.
POLLUTION CONTROL SYSTEMS
KINGWOOD, TEXAS 1-800-659-8271

JOB NO.	946
JOBSITE	TX
REV. NO.	2
DWG NO.	946ELE
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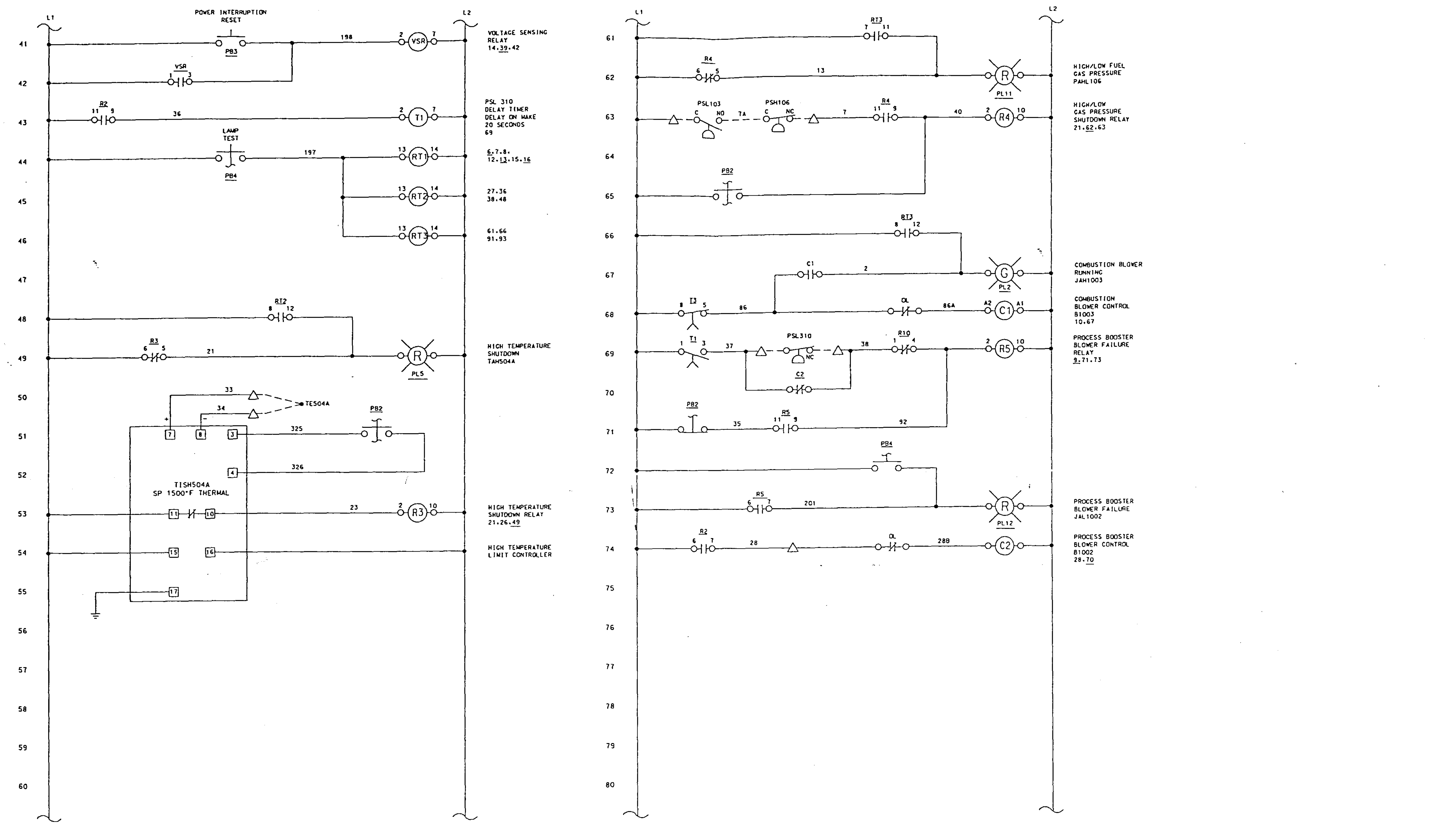

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3. CONTROL CIRCUIT FIELD WIRING TO BE 12-14 AWG WIRE

/\ CONTROL PANEL TERMINAL BLOCK ▽ RECORDER ENCLOSURE TERMINAL BLOCK

·RING OUTSIDE PANELS

\- SUPPLIED BY CUSTOMER

** SUPPLIED BY THERMTECH. FIELD INSTALLED BY CUSTOMER

NO.	DATE	BY	CHK'D	APP'D	REVISION
2	5/13/97	DLN		SH	ADD CUSTOMER WIRE NUMBERS @ TERMINAL BLOCKS NOTE 1.2.3
1	4/10/97	KUB		SH	CHANGE PEN NO.'S ON TIC504B. LINE 81-84

DRAWN KUB
DATE 3/24/97
SCALE NTS
CHECKED
APP'D

CUSTOMER APPLIED EARTH SCIENCES

CONTROL SCHEMATIC

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POLLUTION CONTROL SYSTEMS
KINGWOOD, TEXAS 1-800-659-8271

JOB NO. 946
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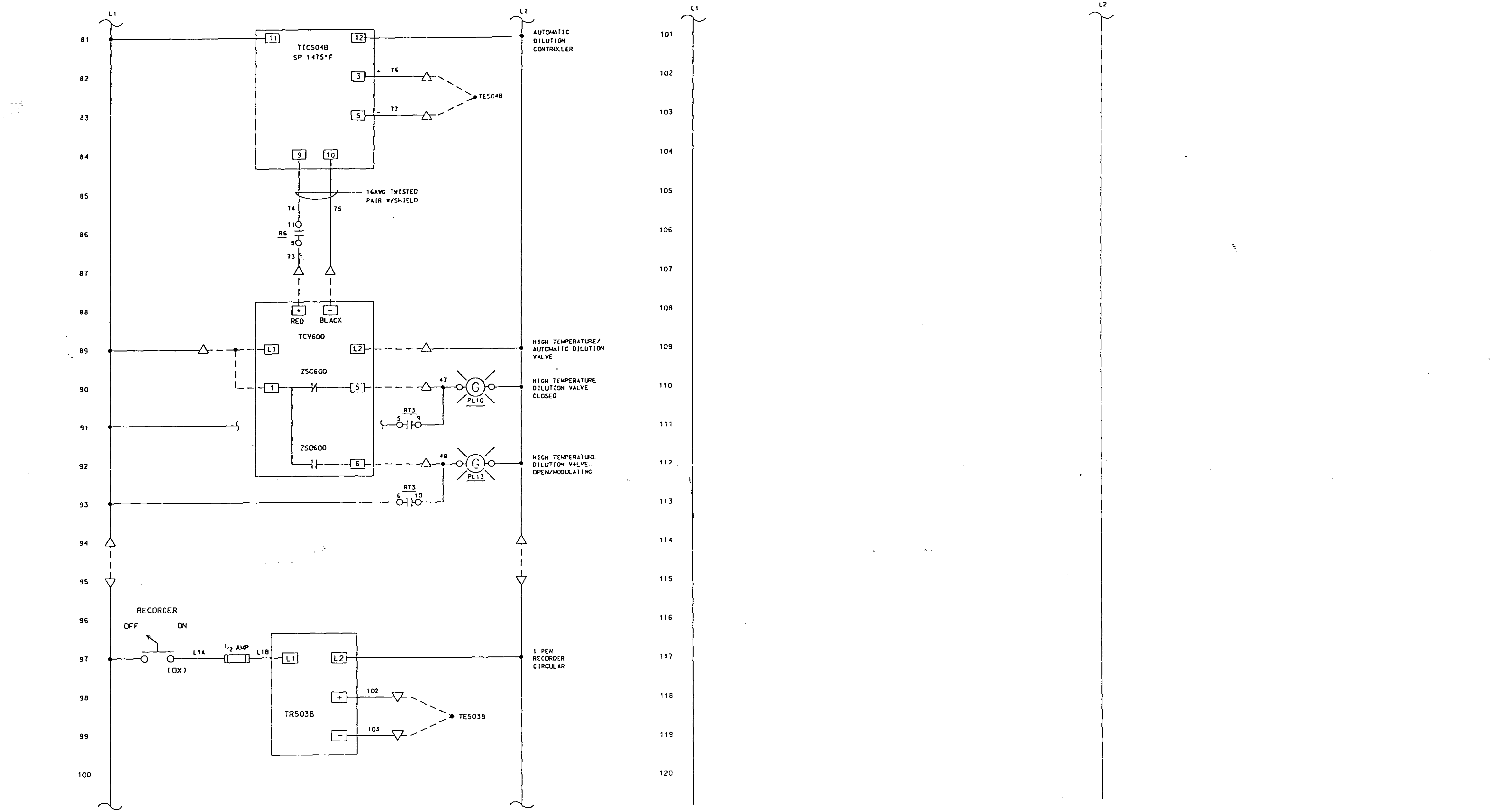

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2. ALL FIELD WIRING TO PANEL TO BE COPPER WIRE, 60°C WIRE INSULATION FOR LESS THAN 100A AND 75°C FOR 100A AND GREATER
3. CONTROL CIRCUIT FIELD WIRING TO BE 12-14 AWG WIRE

△ CONTROL PANEL TERMINAL BLOCK ▽ RECORDER ENCLOSURE TERMINAL BLOCK

WIRING OUTSIDE PANELS

SUPPLIED BY CUSTOMER

** SUPPLIED BY THERMTECH, FIELD INSTALLED BY CUSTOMER

NO.	DATE	BY	CHK'D	APP'D	REVISION
2	5/13/97	DLN		SH	ADD CUSTOMER WIRE NUMBERS @ TERMINAL BLOCKS NOTE 1,2,3
1	4/10/97	KUB		SH	CHANGE PEN NO.'S ON TIC504B, LINE 81-84

DRAWN	KUB
DATE	3/24/97
SCALE	NTS
CHECKED	
APP'D	

CUSTOMER
APPLIED EARTH SCIENCES

CONTROL SCHEMATIC

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JOBSITE	TX
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